MALINE CREEK ASBESTOS SITE CLOSURE AND STREAMBANK STABILIZATION STUDY

ST. LOUIS, MISSOURI

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Superfund

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March 1993

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SECTION I

INTRODUCTION

1.1 Site Location, Description, and History

Maline Creek in St. Louis County Missouri is a tributary of the Mississippi River. Approximately 1/2 mile upstream of its confluence with the river, Maline Creek flows past two industrial properties formerly owned by Certainteed and GAF Corporations. The properties begin about 700 feet east of Bellefontaine Road and are bound on the north by St. Cyr. Road, on the southeast by Riverview Drive, and on the southwest by Maline Creek. The surrounding area is within the corporate limits of the residential villages of Bellefontaine Neighbors and Riverview Neighbors (Figure I-1).

Asbestos containing products such as transite pipe, sheeting, and insulation were manufactured on the site at least as early as the 1920s. When operations were ceased in 1979 closure plans and remediation efforts were initiated for a 17 acre common open asbestos waste dump between the two factories. The remediation activities included importing and grading clean fill material to cap the asbestos pile; installation of drainage elements and a vegetative cover; and construction of a rock blanket along 800 feet of stream bank adjacent to the asbestos pile. The plans were prepared in accordance with the Missouri Solid Waste Management Regulations current at the time and were approved by the Missouri Department of Natural Resources (MDNR). A site inspection conducted by the MDNR in May of 1980 found the effort to be in basic compliance with the regulations, although broken pipe on the creek bank southeast of the Certainteed site was noted. The Certainteed property was subsequently sold to P.G. Investments and the GAF property was sold to Clark Properties of Hazelwood, Missouri.

In 1982 contractors for the St. Louis area Metropolitan Sewer District (MSD) exposed transite pipe and other asbestos products along the creek fronting the Certainteed property during a stream bank brush and debris clearing operation. The MSD began an asbestos cleanup effort under the auspices of the MDNR. Several truck loads of asbestos scrap were removed to the Westlake Sanitary Landfill before it became apparent that the possible extent of in-place material exceeded the cleanup resources available. A wrecking ball was then brought to the site to pound the materials into the bank. The MDNR reported that approximately 1,000 square feet of scrap was left scattered on the upper portion of the bank.

Subsequent inspection of both sites performed by the EPA, Environmental Monitoring and Compliance Branch (EMCB) in May and June of 1988 discovered asbestos scrap along the creek bank, in the creek bed, and scattered about the two properties. Since then periodic inspections by members of the EPA Emergency Planning and Response Branch (EPRB) have been conducted and have discovered more asbestos scrap materials within the creek and its environs. Observations have also been made during field visits by consulants of Ecology and Environment Inc. and TapanAm Associates suggesting that the extent of the scrap disposal area goes far beyond the pile remediated in 1979. It is apparent that hydraulic erosive and scour forces are releasing the asbestos material from the creek banks and washing it into the creek.

Before 1927 Maline Creek described a casual meandering path through the site including one horseshoe bend (Figure I-2). The channel was letter relocated and straightened to create useable space and to provide a low lying area for a dump site. Subsurface soil borings made by PSI during a TapanAm site visit in December of 1992 suggest that the entire length of the channel bed fronting the former Certainteed property may be filled with asbestos scrap (See Appendix A). The horseshoe bend which was located between the Certainteed and GAF factories is the closure site for the asbestos scrap pile remediatied in 1979.

1.2 Problem Definition

Periodic inspections and site visits have demonstrated that progressively more asbestos pipe, sheeting, insulation, and other scrap materials have been observed in and around Maline Creek since the Certainteed and GAF plants closed in 1979. Some of this material is undoubtedly from the 1979 closure site, but most of it is probably being washed into the creek from an upstream source. There is a four or more feet thick lens or stratum of such material perched within the soil matrix of the northeast creek bank. This lens apparently begins on a bend at the northeast corner of the Certainteed site and may extend 1400 feet downstream to the 1979 pile. It is part of the asbestos scrap used to fill the former Maline Creek channel as suggested by observation, subsurface borings, and the 1927 channel relocation drawing.

Storm water runoff has increased dramatically in the Maline Creek watershed since the 1920's as it has been developed and become more urbanized. The channel , therefore, has been increasing its conveyance to accommodate the greater flows by incising its bed and banks. It has also been attempting to re-establish itself within its former channel through the unique combination of erosive inertial and frictional forces unleashed at channel bends. These factors have conspired to undermine Maline Creek's northeast bank at the Certainteed GAF site, and have begun an erosion- scour embankment collapse cycle. As portions of the bank collapse large amounts of asbestos scrap slide into the creek to be washed downstream.

Most of the asbestos scrap consists of stable transite pipe. However, friable asbestos cloth insulation, and friable solidified slurry are present. Furthermore, natural weathering processes, especially freeze-thaw cycles in the creek waters accelerate the disintegration and hence friability of the transite pipe. Airborne fibers from this material pose a public health hazard to adjacent residential areas.

1.3 Statement of Purpose

This study was initiated to investigate the sources of the asbestos materials observed in Maline Creek, to identify the hydraulic mechanisms responsible for exposing and transporting the scrap through the creek, and to suggest three alternate remediation avenues for the site. The proposed remediation alternatives will have two components: cleanup and disposal methods for the exposed asbestos scrap in the creek bed and its environs; and channel rehabilitation and stabilization methods to prevent future scour, erosion, and hence asbestos exposure.

SECTION II

SECTION II

EXISTING CONDITIONS

2.1 Maline Creek Watershed Hydrology

The Maline Creek Watershed comprises 25.3 square miles of largely urbanized land including a small part of northern St. Louis City, all or parts of 22 other municipalities, and portions of unincorporated St. Louis County. The watershed forms a well defined dendritic network with 10.6 miles of main channel flanked by 25.6 miles of tributary channels, ranging in length from 1.4 to 4.2 miles. The area's topography is characterized by gentle sloping surfaces. Local relief is less than 300 feet and the main channel bottom slope is typically less than 1/2 foot in 100 feet.

Precipitation in the region is delivered fairly uniformly throughout the year and averages 37 inches annually. Storms seen in Missouri, however, conform to the United States Soils Conservation Service model Type II. Such storms are typically high intensity-short duration events resulting in high peak discharges during low times of concentration.

In urbanized settings, development renders large tracts of land impervious and alters natural drainage patterns. Such modifications reduce absorption and transpiration processes, and channelizes runoff thereby increasing velocities and shortening concentration times. Increases in effective runoff by factors of 4 are not uncommon in watersheds where high density development has taken place.

The St. Louis District Corps of Engineers modeled Maline Creek hydrologically and hydraulically for the survey report "Water Resources Investigation, St. Louis Metropolitan Area, Missouri and Illinois" in September of 1980. Those hydrological and hydraulic data were subsequently updated by the Corps in the "Maline Creek Flood Control Re-evaluation Study" of 1988. The two studies investigated the impacts of a variety of alternate flood control plans on anticipated "future condition" hydrographs routed for 0.2%, 1.0%, 2.0%, 4.0%, 10.0%, 20.0%, and 50.0% probability storm events. The "recommended plan" hydrograph for the 1.0% (100 year) probability storm was selected as the benchmark event for this study. This storm delivers a peak discharge of 19,972 cfs to Maline Creek Station 0.541 miles (above the mouth of the Mississippi River) which is located just upstream of the Metropolitan Sewer District Drop Structure and downstream of the Clark Properties site at 9215 Riverview Boulevard formerly owned by GAF Corporation.

2.2 Maline Creek Hydraulics

The Metropolitan Sewer District Drop Structure at Station 0.527 miles is the point of control for water surface profiles along the Maline Creek reach adjoining the Certainteed-GAF asbestos fill sites. Throughout the reach, flow is severely restricted as a result of low conveyance due to mild channel slopes (<0.2%); inadequate cross sectional area; irregular (non prismatic) sections and transitions; and the presence of natural and man placed roughness elements such as brush, trees, rocks, failed riprap, construction debris, asbestos cement pipe, buildings, etc. Discharge is, therefore, in the subcritical flow regime and results in flooding conditions for storms of 10% probability (10 year) or greater. Extensive flooding is seen during the 1% (100 year) event when most of the Certainteed-GAF site and much of Bellefontaine Neighbors west of the creek are inundated (Figure II-1).

The concrete paved MSD drop structure lowers the channel bottom by approximately 6 feet over a 400 feet long reach. The channel width is 43 feet with paved sideslopes ranging from 1 1/2H to 1V to 1 3/4H to 1V. At the upstream entrance to the structure the natural channel width is 35 feet whereas the exit channel width is 65 feet. The channel continues to widen as it progresses downstream to its confluence with the Mississippi. A dramatic drop in elevation (8 feet for the 1% storm) is therefore seen in water surface profiles through the structure. This drawdown indicates that no influence is exerted on upstream backwater conditions by the Mississippi River or lower Maline Creek reach during local storm events.

2.3 Soils - Embankment Conditions

Soils in the Maline Creek watershed were extensively investigated by Simons, Li and Associates for the "Maline Creek Qualitative Erosion and Sedimentation Investigation Report" prepared for the St. Louis District Corps of Engineers. Subsequent geotechnical work was also initiated by the Corps for the 1988 "Maline Creek Re-evaluation Report."

According to the reports the channel bed is comprised primarily of silts and clays with some fine sands. An exposed shale outcropping was found and some portions of the bed consist of exposed clays incised by the channel. Other than the shale and exposed clay there are no natural features to offer resistance to channel degradation. However, man made improvements such as concrete encased sewer lines, rubble or riprap, and a variety of channel linings serve as gradient and hydraulic control devices of varying effectiveness.

The upper 10 to 15 feet of Maline Creek embankment is composed of very low clay content loess. Below this layer a high clay content loess or stiff clay is encountered.

The more cohesive clayey soils most frequently occur in the middle and upper reaches of the creek above Bellefontaine Road. The lower reach through the Certainteed-GAF asbestos site embankment conforms to the low clay content loess profile. Loess soils are highly erosive glacial aged aeolian deposits of silt sized particles with varying degrees of cementation. Those in Maline Creek have been extensively reworked and redeposited through fluvial processes to form a silty alluvium on the flood plains.

The condition of the embankments in the vicinity of the Certainteed-GAF sites ranges from reasonably stable to severely distressed. Generally, well vegetated tangential sections with mild bank slopes appear sound; while sections with bare, steep or vertical banks, around bends are undergoing a dynamic cyclical undermining and collapse process.

Two 50° bends to the right (looking downstream) approximately 1/3 mile apart are within the Certainteed-GAF reach. These were created in 1927 when the original meandering channel northeast of the present day channel location was filled. The first bend is 650 feet east of Bellefontaine Road at the confluence of Maline Creek with its Riverview Branch tributary. It precedes unstable embankment conditions which continue downstream for almost 1/4 of a mile and probably represents one of the more extreme examples of streambank erosion and degradation along the creek. Even vegetated portions of the bank with trees and saplings are being undermined by flood waters. These then collapse leaving loose material which is subsequently carried downstream. Among the materials found in the collapsing bank underlying the vegetation is the thick layer of asbestos waste products which was used to fill the old creek channel.

The other bend is located at the 1979 Certainteed-GAF asbestos waste pile. Although some side slopes in the vicinity of the pile are mild and relatively stable for the present, there is evidence that natural erosive and scouring processes are taking place; especially along the steeper slopes. The 1979 remediation effort included a 25 feet by 800 feet rock blanket placed along the regraded creek bank. This blanket has largely failed and has been washed into the channel bed or has been carried downstream by flood waters. Such failures of erosion control measures are common in Maline Creek and were frequently noted in the Simons, Li, and Associates report.

2.4 Erosion-Scour Causes and Mechanisms

The fundamental reason for the progressive erosion and scour processes seen in Maline Creek is the increasing rainfall runoff load placed on the channel in conjunction with the ongoing urbanization of the watershed. Channel equilibrium has not been achievable in the face of continuous development. Because the Certainteed-GAF site is located at the downstream extremis of the 25.3 mile watershed it is subject to the added runoff from virtually any new activity. There are two consequential impacts on the channel. It must increase conveyance to accommodate the added flow and a sediment deficit is created in comparison with the new transport capacity of the stream. Over the years these phenomena have resulted in both bank erosion and an observed one to three feet degradation of the channel profile.

A related consequence of urbanization with particular application to this site is the developers' habit of straightening and relocating channels to maximize useable space. Simons, Li, and Associates noted in their report that Maline Creek has a particular "tendency to return to a meandering pattern." This tendency is especially evident along

St. Cyr Road east of Bellefontaine Road and at the Riverview Branch tributary bend in the creek. The undermining and erosion processes in those areas are in part a result of the creek's attempts to re establish itself in its former channel bed. The Simons, Li, and Associates report also concludes that future channel bed degradation in Maline Creek will probably diminish because the watershed is now almost completely urbanized and most of the bed has been incised to the more scour resistant clay layer. However, erosion of the bank remains a major problem and is of special concern for the fragile low clay content loess banks below Bellefontaine Road.

Erosion-scour processes are complex phenomena with a variety of concurrent causes. Foremost among them is the tractive force (shear or drag force) acting on the channel bed and sides in the direction of flow. It is often associated with a "maximum permissible velocity" which in alluvial silts similar to the loess seen in Maline Creek is 2 fps for clear water and 3.5 fps for water transporting colloidal silts. Given the sediment deficit in the flow noted by Simons, Li, and Associates, the "maximum permissible velocity" for Maline Creek is probably closer to the lower 2 fps figure. That velocity is low even for tranquil subcritical flow and is probably often exceeded throughout the length of the creek. Where bends, obstructions, and sudden transitions occur additional inertial and frictional forces are introduced which accelerate the flow. The new acceleration components, in the form of velocity increases and direction changes results in higher momentum, vortices, and eddying currents which tend to promote scour and erosion. Both natural and manmade features inducing such acceleration are common to the creek. Simons, Li, and Associates routed the 10% and 1% probability storms through 14 Maline Creek bridges and noted that most velocities were considerably in excess of 3.5 fps.

The spiral currents generated as water moves through bends are of particular concern in the Certainteed-GAF reach. This phenomenon is peculiar to subcritical flow and accounts for much of the embankment scour which can be seen even in some relatively tranquil streams. Such currents describe a helical path in the direction of flow and introduce transverse velocity components to the channel section (Figure II). These currents are believed to be caused by filamental velocity differences between the center of the channel and the channel wall induced by friction; centrifugal force which deflects water particles from straight line motion; and a vertical velocity distribution in the approach channel which initiates the spiral motion. Looking downstream, a bend to the right induces counterclockwise motion, while a bend to the left induces clockwise motion. Such currents are probably the primary reason for the severe undermining process seen at and below the Riverview Branch tributary bend. Spiral currents tend to persist for some distance downstream when a curve is followed by a long straight tangent and, therefore, their impact is not merely local. The extensive damage done along the Certainteed-GAF northeast bank well below the bend is a prime example of their effect.

In addition to the dynamic hydraulic forces acting on the channel and its banks induced by the current, there are local erosive forces at play. Among these is the sheet flow over the stream banks initiated by rainfall runoff or receding flood waters from contiguous drainage areas. Such runoff causes gullying and rilling in proportion to the erosive potential of the soil and the erosion resistance ability of the channel lining.

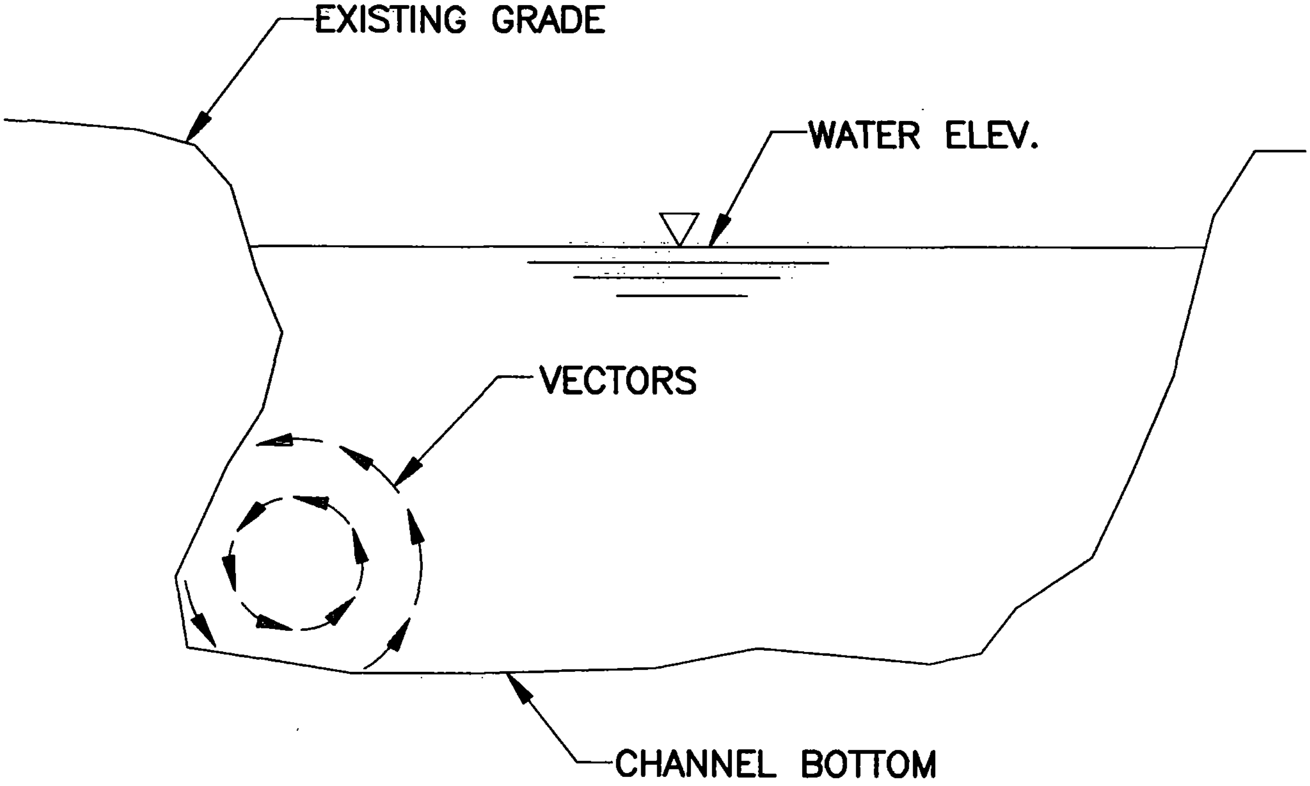

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FIGURE II-2
CREEK SECTION SHOWING SPRIAL FLOW VELOCITY VECTORS

Differential pressures between the soil envelope and the open channel section also often initiate embankment collapse. This is the sudden draw-down effect most often seen after a period of sustained rainfall when surrounding soils are saturated to capacity. The shear strength of the soil-water mixture is considerably less than that of the soil in its normal state, while the weight and hence the pressure exerted by the mixture is much greater than normal. When the hydrostatic pressure opposing the saturated soil pressure is relieved during drawdown as flood waters recede, a precipitous collapse of the bank often ensues.

SECTION III

SECTION III

MALINE CREEK ASBESTOS STUDY

3.1 Introduction

The approximate boundaries and depth of the asbestos waste pile in the Maline Creek area was determined by subsurface drilling operations. Twelve bore holes were drilled using a profile auger each to a depth of twenty feet. The surface contamination was determined during the site inspection.

3.2 Surface Contamination

Asbestos containing materials are exposed in the creek bank, bottom of the river bed and on the surface. The most visible contaminations is along the east bank of Maline Creek near St. Cyr road, where a stratum of white asbestos containing material is exposed to the surface. This layer of asbestos material is about two feet below the surface and is about two to five feet in thickness. This statum is exposed along the bank for about 300 feet in length (Figure III-1 and III-2).

The majority of the asbestos pile in the creek bed is caused by collapse of asbestos material from the bank into the creek bed where water has undermined the soil beneath the stratum (Figure III-3 and III-4). Water has subsequently carried some of this debris downstream, scattering pieces of cement asbestos pipes along the entire length of the creek.

On the surface, in the wooded area along the top of the east bank of the creek, broken pieces of pipe lie scattered amongst the rip-rap and vegetation. More asbestos material is exposed to the surface in the northern part of the property where the eastern cap is

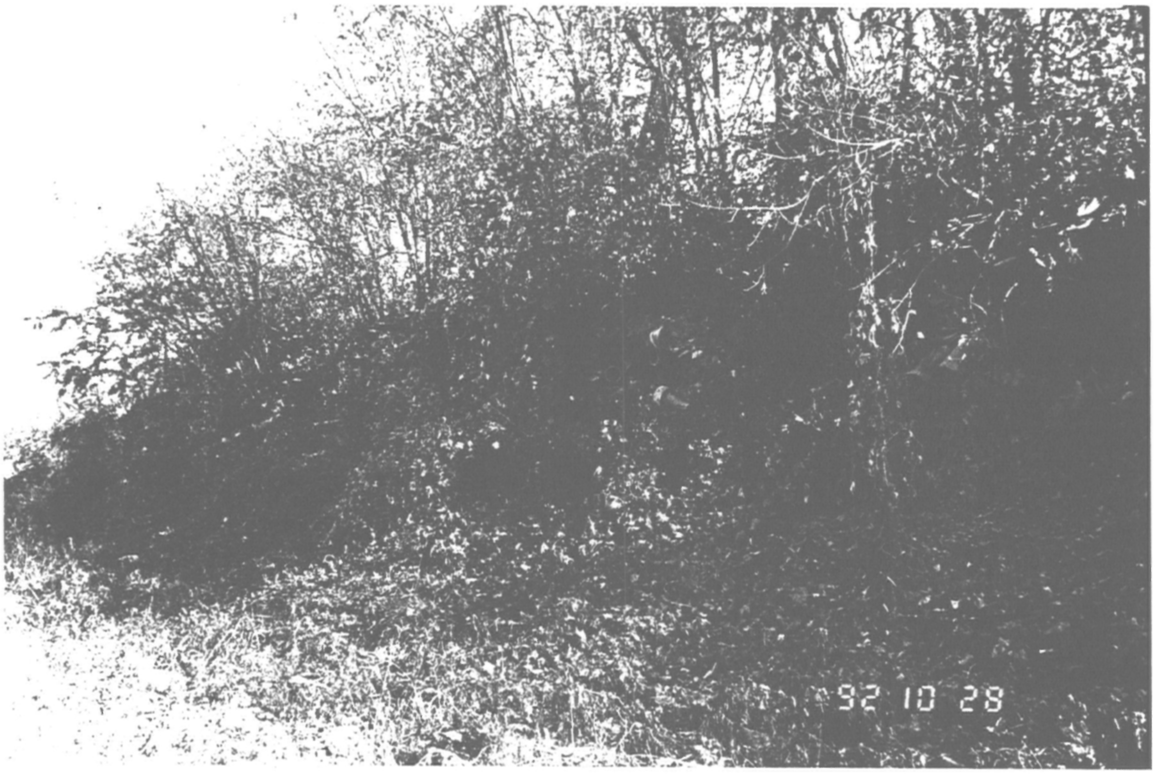

Figure III - 1 Looking North at approximately 1/2 mile SE of Riverview Branch tributary.

Figure III - 2 Close-up of NE bank from Riverview Branch tributary, approximately 1/2 mile SE of tributary to show stratum of asbestos materials

Figure III - 3 Looking SE from Riverview Branch tributary to show asbestos material on creek bed.

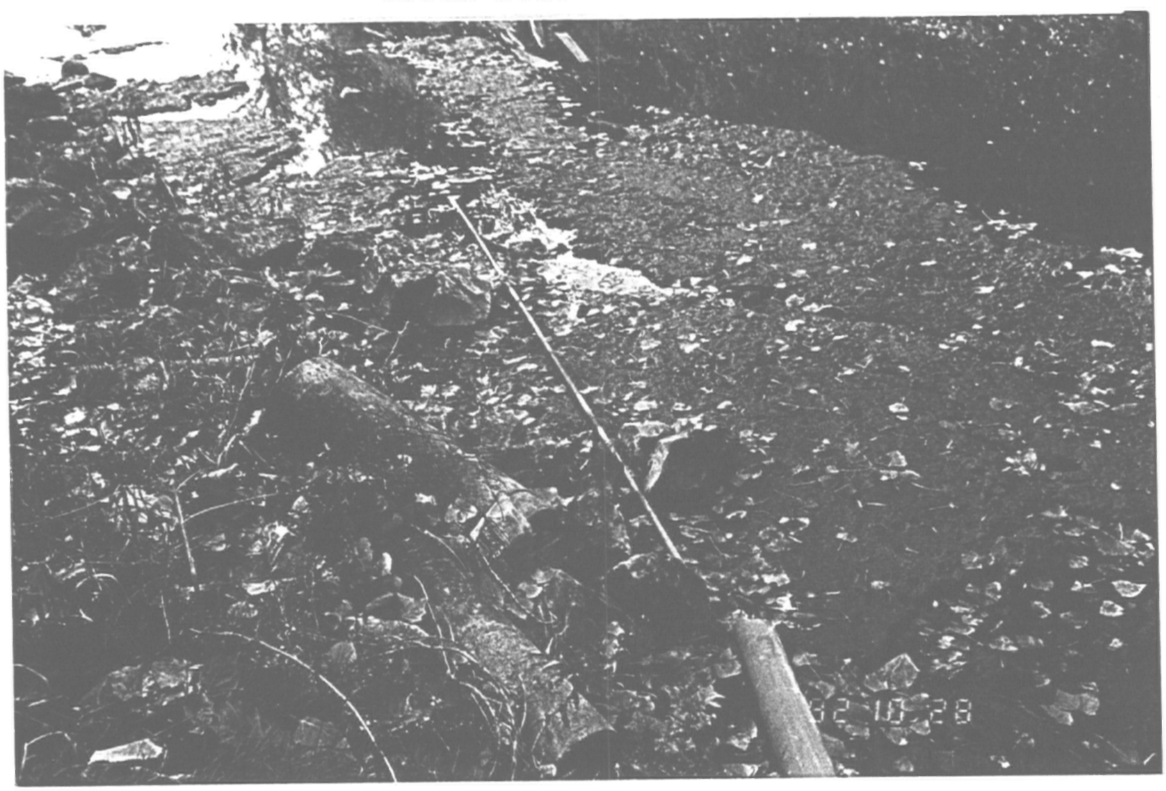

Figure III - 4 Close-up to show asbestos material scattered on creek bed, looking south at Maline Creek from Riverview Branch tributary.

only a few inches thick. Broken pieces of pipe litter the asphalt parking lot where half buried cement asbestos pipes are used as wheel stops. Small piles of asbestos debris are scattered around the southern edge of the property which abuts the old GAF property. Asbestos pipes are also exposed around the base of the high voltage electric wire transmission Tower located at the southern edge of the main parking area.

3.3 Subsurface Contamination

Twelve bore holes were drilled to determine the subsurface level of contamination. The location of bore holes shown in Figure III-5 and the bore hole logs are included in Appendix A.

Materials encountered in the boring consisted of fill materials overlying alluvial deposits consisting of silty clays and clayed silts. The fill material consisted of cement asbestos debris, sand, gravel and silty clays.

It is evident from the borehole data that much of the fill material used during the 1927 creek re-alignment project consisted of cement asbestos debris. The thickness of the asbestos bearing fill material ranged from seven feet to the full twenty feet depth of the boring. Fourteen feet of asbestos material was encountered at boring location B1, twenty feet at boring location B4 and eight feet of asbestos material at boring location B8. The soil cap covering the asbestos debris varied from one to two inches in the north to six to seven feet in the south at boring location B6.

3.4 **Asbestos Materials**

The vast majority of exposed asbestos containing materials (ACM) located on the subject property is cement asbestos pipe sometimes referred to by the brand name Transite. Other asbestos containing materials identified among the debris include broken pieces of corrugated cement board, pipe collars, impregnated cloth, pipe insulation and solidified slurry mixtures (Figure III-6 and III-7). According to NESHAPs regulations, the pipe and siding materials identified in the area are classified as Category II nonfriable ACM. These are materials which release significant levels of asbestos when crumbled or pulverized.

The EPA Final Rule Act 40 CFR 763 subpart E, defines asbestos containing materials as any material which contains more than 1% asbestos. Insulation and cement pipe debris identified in the bore holes contained about 85 to 90% asbestos. The cement board contained about 20% asbestos. The primary asbestos mineral found in these materials is chrysotile. Crocidolite was also detected in the pipe and insulation materials.

Friable materials identified at the site include pipe insulation, impregnated cloth and solidified cement slurry. Weathering and deterioration of non friable materials may lead to delamination, where the material begins to split and pull apart thus releasing fibers.

The materials in the creek bed showed signs of advanced deterioration probably due to water erosion and freeze thaw actions. Other factors noted as contributing to the breakdown of the non friable materials include stress induced by plant roots and vehicles running over the materials scattered in the parking area.

Figure III - 6 Transite pipe, connectors and pipe collars along NE bank from Riverview Branch tributary.

Figure III - 7 Close-up of asbestos pipe in solidified slurry.

3.5 Asbestos Regulation

Asbestos is one of the known human carcinogens. Inhalation of airborne asbestos fibers can produce lung cancer, mesothelioma and other respiratory diseases. Asbestos is regulated in workplace by Occupational Safety and Health Administration (OSHA). Regulations such as NESHAPs Final Rule were promulgated to reduce the emission of asbestos fiber into the air. US EPA has implemented regulations for asbestos present in schools, for asbestos removal from buildings, asbestos concentrations in drinking water and disposal of asbestos waste material. However, no regulations exists for exposure to asbestos in ambient air, non-occupational settings near asbestos deposits or asbestos construction materials such as Maline Creek asbestos dump site. Under the EPA 1996 Safe Drinking Water Act & Regulations, public water systems may contain no more then 7 million asbestos fiber greater than 10 microns in length per liter.

3.6 Hazard Potential

According to the PSI report it is not likely that a person walking in the area would inhale a hazardous amount of asbestos fibers. However, due to the increasing amount of exposed material, and the continued deterioration of the materials, the potential for exposure increases with time.

The possibility of asbestos fibers being present in the creek water poses two scenarios which would result in being hazardous to the public. The first scenario is that the fibers in the water will be deposited on a surface which when dries causes the fiber to become airborne. Due to the quantity of material in the creek and the continual change in water level in the creek, this situation is a viable concern. The second scenario is that the fibers make their way to the Mississippi River and then into the intake of public water system.

Investigation of exposures to environmental asbestos by Black et al, (1989) suggested that wind erosion is not a significant mechanism in asbestos fiber entrainmet at the Superfund site at Alviso, a suburb of San Jose, California. They suggested that mechanical soil disturbance action may be more important than wind in creating asbestos fiber. It is more likely that asbestos in community air is caused by soil disturbing activities such as vehicle traffic.

3.7 Removal & Handling Recommendations

3.7.1 Removal

Due to the increasing risk of exposing the public to potentially hazardous levels of airborne asbestos fibers, and to prevent the further pollution of Maline Creek, three remedial alternates are proposed. The alternate proposes to use the asbestos material to stabilize the banks of the creek. However, in order to accomplish the task of stabilizing the creek bank, some of the asbestos-containing material on the property adjacent to the bank will be disturbed. In addition, those materials which have already fallen into the creek bed will be removed and used as fill material or disposed of properly.

Prior to mobilizing a contractor on site it is recommended that the EPA conduct a town meeting with the local residents and interested parties to inform them of what will be taking place. By performing this service beforehand it will help to alleviate unwarranted fear and concern that may otherwise arise during the project.

3.7.2 **Handling**

During the process of cleaning up and stabilizing Maline Creek, protective measures should be taken to insure the safety of personnel involved in the cleanup work and the general public. Although most of the ACM involved is of the nonfriable variety, it would not be possible to separate out the friable material for separate handling and disposal. In addition, it is not practical to assume that the nonfriable materials will not be broken during handling. Due to the size and quantity of asbestos-containing materials involved, heavy equipment such as bulldozers and dump trucks will have to be used to perform most of the abatement work.

Essentially this project will be the reopening of an existing inactive asbestos waste disposal site. This type of operation is covered by the NESHAP regulations. Standard 61.151 of the Final Rule pertains to inactive waste disposal sites for asbestos mills and manufacturing and fabrication operations. In this standard it states that written notice must be provided to the NESHAP administrator at least 45 days prior to excavating or otherwise disturbing any asbestos-containing waste material that has been deposited in a waste disposal site. The administrator in this case is the St. Louis County Department of Health, Air Land & Water Branch, Air Pollution Control Section. This agency has been given the task of enforcing the NESHAP regulations by the Missouri Department of Natural Resources, who in turn was tasked by the EPA. The County Department of Health also requests that a notification of asbestos removal be submitted on their standard notification form.

After the abatement/restabilization work begins the site then becomes classified as an active waste disposal site. Standard 61.154 of the NESHAP regulations provides the guidance for this type of operation. The regulation states that during operations there must be no visible emissions to the outside air. As an option to this rule, the operator of the disposal site may cover the asbestos-containing waste material, that was deposited that day, with either six inches of compacted soil or an effective resinous or petroleum-based dust suppression agent. Alternate dust control methods may be used if approved by the EPA. If the compacted soil option is not utilized, the site must be fenced off and warning signs posted to notify the public of the dangers of breathing asbestos dust.

Although the NESHAP regulations provide us with the minimum requirements for conducting a task such as this, due to the creek and close proximity of the work site to a residential neighborhood, additional precautionary measures are recommended. Protective measures must be taken to assure the safety of not only the general public, but also those personnel performing the work.

The primary goal to achieve in regards to maintaining a safe environment and complying with current regulations during relocation of the asbestos material is to release no visible emissions. In order to accomplish this goal, proper handling techniques will have to be practiced and special engineering controls utilized. Materials should be wetted before removal and kept wet during handling. Dust suppressants may be used on an as-needed basis in addition to a nightly cover of six inches of soil placed over the exposed material. Filtering or settling of the creek water will be necessary to prevent contaminated effluent from continuing on down stream. A decontamination unit should be installed to allow an area for workers to change clothes, to establish the boundary between the controlled area and clean area, and to provide a common point of ingress and egress to the area. Under the Resource Conservation and Recovery Act (RCRA) 40 CFR 257, EPA requires that access be controlled to prevent exposure of the public to potential health and safety hazards at the disposal site. Therefore, it is recommended that warning signs should be posted notifying the public of the danger of breathing asbestos dust, and temporary fencing installed around the work site to keep unauthorized people out of the area. Gates which can be locked during off hours should be installed. Personnel working in the area, including equipment operators, should have proper training in the handling and removal of ACM, and be equipped with personal protective equipment applicable for these type of activities. After the abatement work is complete, all tools, equipment, and vehicles used on the project should be decontaminated and inspected prior to leaving the job site.

The purpose of maintaining no visible emissions is to keep the airborne asbestos fiber concentration level to a minimum. A comprehensive air monitoring program should be maintained throughout construction to assure that the proper level of protective equipment is being worn by the workers, to confirm that adequate wetting and handling procedures are being practiced, and to assure the general safety of the public in surrounding areas. Air monitoring also provides a documented record of the environmental conditions throughout the project.

3.8 Disposal Method And Location Recommendations

3.8.1 Disposal

The transporting and disposing of ACM is a complex and expensive task. Transported materials must be containerized and moved in a enclosed vehicle. The remainder of asbestos debris must be taken to a sanitary landfill approved for the disposal of asbestos waste. Special paperwork must be completed by all parties involved in taking these materials off site to another location. It is recommended that as much of the asbestos material be placed back onto the subject property to be used for channel stabilization as fill material.

3.8.2 **Location**

The removed asbestos material will be used as fill behind the retaining structure constructed to stabilize the creek bank.

Materials buried on site should not be compacted until the daily six inch cover has been put in place. In accordance with NESHAP regulations, all asbestos-containing debris must be covered with a minimum of six inches of soil and suitable vegetative cover prior to final closing of a landfill. However, EPA 40 CFR 763, the Final Rule, requires thirty inches of soil cover be placed over the six inch daily cover prior to final closure of an asbestos landfill. Although 40 CFR 763 pertains to asbestos removal in schools, it is recommended that this standard of a thirty six inch cap be utilized due to the size of the dump site and to prevent erosion and exposure of the buried material in the future.

Any materials which can not be placed back on the site property may be taken to the Missouri Pass Landfill on Page Street in St. Louis County, or any other sanitary landfill which accepts asbestos waste. All asbestos wastes transported off site must be in impermeable containers. A practical means for a large scale project such as this one would be the use of "bladder bags"; large polyethylene liners which fit inside 20 or 40 cubic yard roll-off type waste containers. Warning signs would be posted on the containers during loading and unloading. The containers would be covered during transport.

SECTION IV

SECTION IV

ENGINEERED SOLUTIONS

4.1 General Discussion- Stabilization Techniques

Channelization is a dynamic process, yet nature has means of stabilizing or maturing streams. One method is the meandering mechanism, which does so in two ways. It reduces channel bed slopes and hence flow velocity by lengthening channel routes, and it introduces compound curves and countercurves which dissipate more energy and further reduce velocity. By using compound curves and reverse curves, and by avoiding long tangent sections between curves, nature dampens and compensates for the spiral currents often seen at bends in man made or man modified channels. The results then of the meandering phenomenon are lower flow velocity leading to a lower tractive force, and the dampening or elimination of the transverse forces caused by spiral currents.

Another method nature uses to mature a stream and control erosion is through sediment transport. When the sediment transport capacity of a discharge and the sediment load in that discharge are in equilibrium, no further erosion may take place. An urbanized watershed, however, delivers far more runoff at higher velocities than in its undeveloped state, and has had its pervious soil surfaces reduced. Thus sediment transport capacity has been increased, while a large percentage of the overbank sources of silt have been eliminated. The channel bed and bank then become the primary source of material to satisfy the increased transport capacity demand.

Of course the channel cannot be returned to its former meandering state and the watershed cannot be de-urbanized. Therefore, other methods must be used to prevent future erosion and re-exposure of the asbestos. TapanAm proposes three alternatives to stabilize the creek. They are essentially variations on the same themes and involve reinforcing the channel bed and embankments to resist the hydraulic forces at work, and the construction of a more prismatic and transitionally smoother channel to dampen some of those forces. Local erosive phenomena will be addressed by providing surface intercept and sub-surface drainage features where appropriate. The three alternatives differ primarily in their materials, thickness, and limits of reinforcement. The selection criteria for these alternates include ease of construction, maintainability, longevity, and cost.

All three of the alternatives have a common asbestos scrap collection and disposal method. Essentially, all asbestos material within the channel bed and along the southwest banks will be collected and placed in the northeast banks. The scrap will be sealed in benched lifts with soil to act as a binder. The lifts will be further sealed in soil prior to channel lining construction (Figure IV-1). This will involve shifting the channel bed to the southwest to provide working space for bench construction and to provide soil borrow to construct the benches and rebuild the embankment.

After examining a variety of channel section shapes and linings along the improved reaches of Maline Creek, including many which have failed, Simons, Li and Associates concluded that three typical sections were appropriate for use in modifying the creek depending on local hydraulic conditions (Figure IV-2). The Metropolitan Sewer district which has experimented with a number of section shapes and linings will accept most competently engineered solutions. However, the MSD will only assume maintenance responsibilities for vertical reinforced concrete retaining walls with reinforced concrete channel bed linings. Retaining wall structures are extremely expensive. One installed

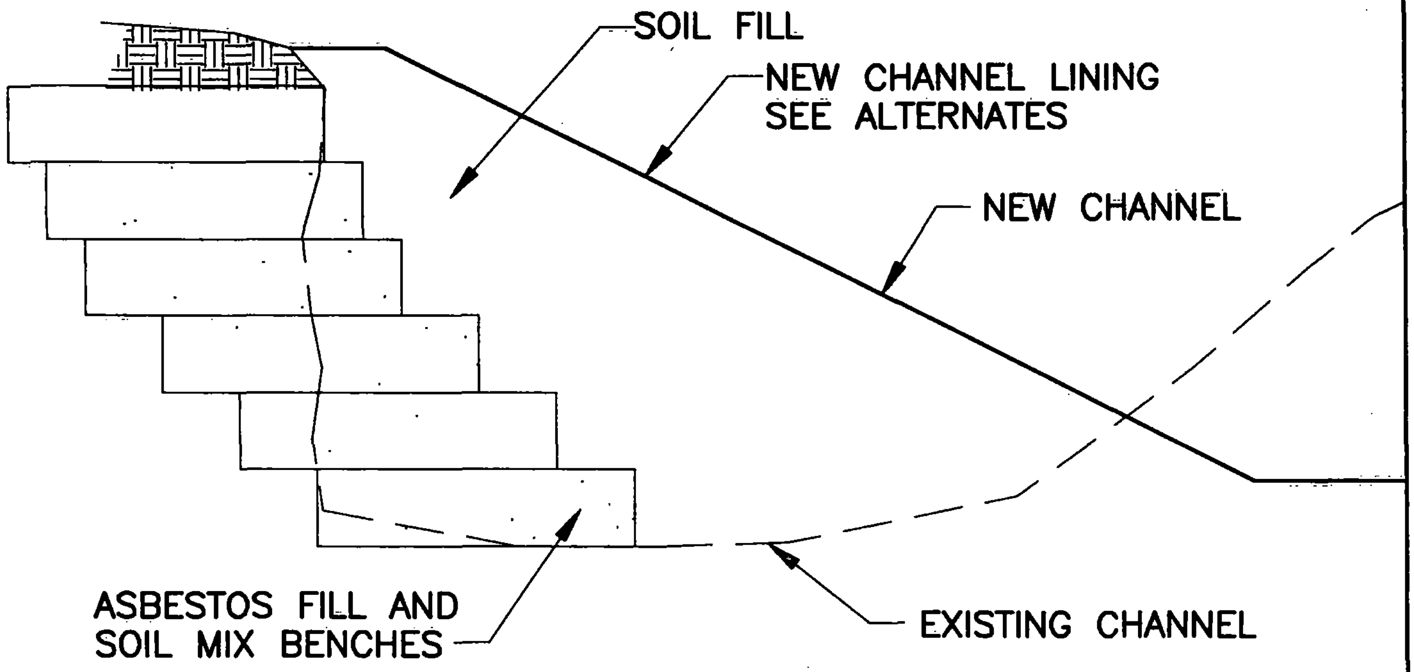

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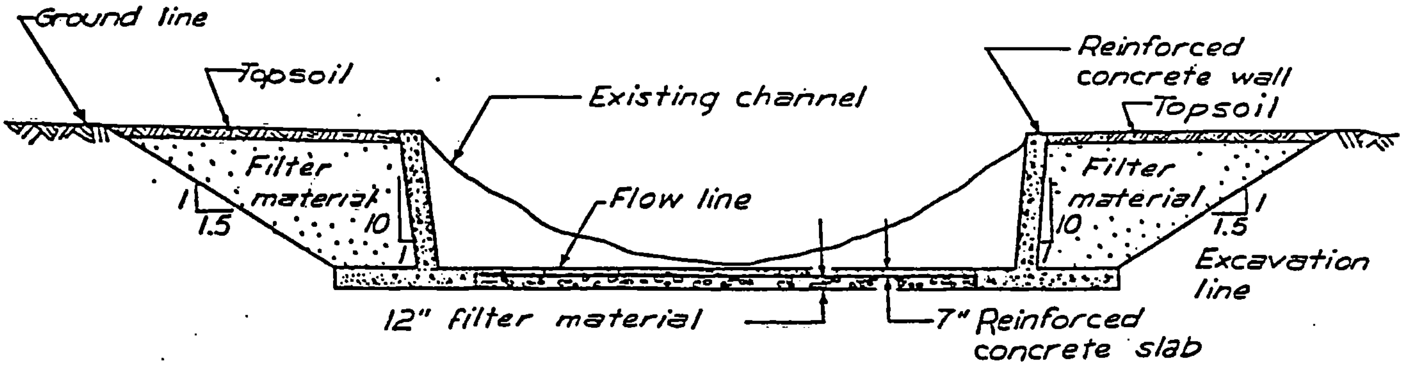
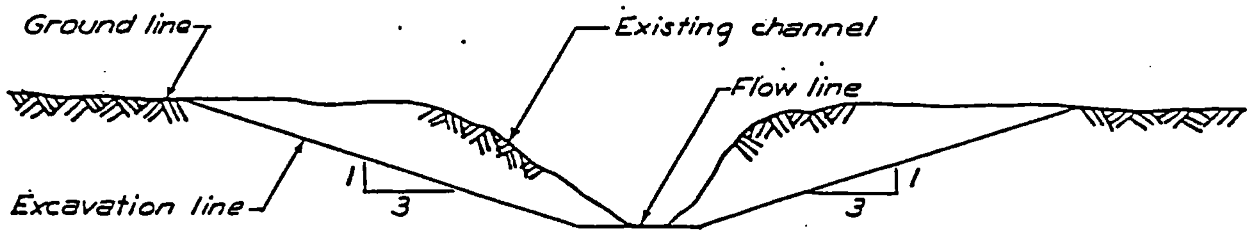
FIGURE IV-1
SUGGESTED ASBESTOS DISPOSAL & STABILIZATION TECHNIQUE



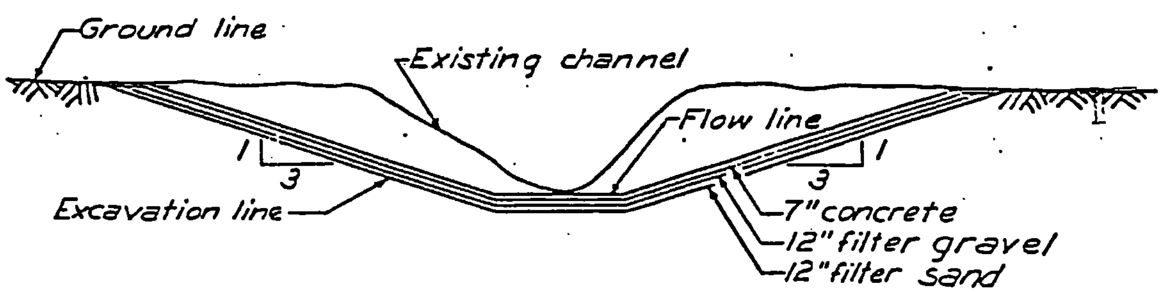
U-SHAPED CONCRETE CHANNEL

NO SCALE



TRAPEZOIDAL EARTH CHANNEL

NO SCALE



TRAPEZOIDAL CONCRETE CHANNEL

NO SCALE

Figure IV - 2 **Typical sections of proposed channel modifications. By Simons, Li and Associates (1985)**

on Blackjack Creek, a tributary of Maline Creek, by the MSD cost $700.00 per foot to build. To construct such a channel at the downstream terminus of a 25 square miles watershed subject to the vicissitudes of weather during construction would be prohibitively expensive. Therefore, the preferred MSD solution is not among the alternatives selected for investigation in this study.

TapanAm has, however, selected methods which are consistent with current hydraulic engineering practice, and are cost effective for the desired level of protection. They all utilize methods and materials selected for ease and relative economy of construction and are also compatible with construction in an actively flowing stream subject to the occasional storm.

4.2 Alternate No. One

This alternate offers the greatest protection at the highest cost among the three alternates. It involves lining the entire channel from Bellefontaine Road to the MSD drop structure with concrete (Figure IV-3). The tangent reach of the channel bed between the two 50° right bends will be shifted to the south by as much as 40 feet in some places and will be increased to a width of 50 feet. The bed will be lined with a 12" thick gabion revetment, while the banks will be sloped at 2 to 1 and will be lined with an 6 inches thick Geoweb cellular confinement system infilled and capped with 8 inches of concrete (Figure IV-4).

The construction material quantities and opinion of probable cost for this alternate are listed in Table IV-1.

TABLE IV-1: Estimated Quantities and Opinion of Probable Cost for Alternate No. One.

Item	Quantity	Unit Price ($)	Cost ($)
Clearing and Grubbing	7 AC.	4,000.00	28,000.00
Earthwork	17,000 Cu. Yd.	10.00	170,000.00
Onsite Asbestos Disposal	5,000 Cu. Yd.	25.00	125,000.00
12" Thick Gabion Revetment	14,500 Sq. Yd.	40.00	580,000.00
6" Geoweb 8" Conc. Syst.	11,800 Sq. Yd.	40.00	472,000.00
8" Geoweb 10" Conc Syst.	12,400 Sq. Yd.	50.00	620,000.00
Geotextile Fabric	24,200 Sq. Yd.	2.00	48,400.00
6" Granular Filter	24,200 Sq. Yd.	5.00	121,000.00
Sub Total			$ 2,164,400.00
Construction Contingencies (20%)			$ 432,900.00
TOTAL			**$2,597,300.00**

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The approach and departure reaches from Bellefontaine Road to the first bend and from the second bend to the MSD drop structure respectively will have a 35 feet wide 12" thick gabion revetment bed placed within the existing channel bed. The embankment slopes will be 1½ to 1 and will be lined with an 8 inches thick Geoweb system infilled and capped with 10 inches of concrete (Figure IV-4).

4.3 Alternate No. Two

Alternate No. Two is the least costly of the three. It differs from Alternate No. One in that concrete is used as a channel lining only in the vicinities of the two bends; the channel is shifted farther to the southwest to accommodate milder embankment slopes; and no channel work is proposed upstream of the Riverview Tributary bend or downstream of the 1979 remediation pile bend (Figure IV-5).

Both banks of the creek within the tangent reach between the two bends will be earth fill sloped at 3 to 1 and will be surfaced with a vegetated turf reinforcement matrix. The bend embankments will be sloped at 1 1/2 to 1 and will be lined with 8 inches thick Geoweb system infilled and capped with 10 inches of concrete (Figure IV-6).

The channel bed will be lined with a 12 inch thick gabion revetment, while approximately 1000 square yards of 18 inches thick grouted riprap will be placed at the downstream end of the new construction. Fifteen feet deep sheet piles will be placed across the channel's upstream and downstream ends to prevent undermining and headcutting.

The construction material quantities and opinion of probable cost for Alternate No. 2 are contained in Table IV-2.

TABLE IV-2: Estimated Quantities and Opinion of Probable Cost for Alternate No. Two.

Item	Quantity	Unit Price ($)	Cost ($)
Clearing and Grubbing	7 AC.	4,000.00	28,000.00
Earthwork	12,000 Cu. Yd.	10.00	120,000.00
Onsite Asbestos Disposal	5,000 Cu. Yd.	25.00	125,000.00
12" Thick Gabion Revetment	7,400 Sq. Yd.	40.00	296,000.00
8" Geoweb 10" Conc. Syst.	5,800 Sq. Yd.	50.00	290,000.00
Geotextile Fabric	5,800 Sq. Yd.	2.00	11,600.00
6" Granular Filter	5,800 Sq. Yd.	5.00	29,000.00
Turf Reinforcement Matrix and Soil	15,000 Sq. Yd.	6.00	90,000.00
Sod	15,000 Sq. Yd.	2.00	30,000.00
Sheet Piling	3,000 Sq. Ft.	20.00	60,000.00
Sub Total			$1,079,600.00
Construction Contingencies (20%)			$ 215,900.00
TOTAL			$1,295,500.00

4.4 Alternate No. Three

This alternate is similar to Alternate No. Two except that the 3 to 1 sloped reinforced earth embankment on the northeast asbestos site side of the creek is replaced with a 2 to 1 sloped 6 inch thick Geoweb confinement system infilled with 6 inches of concrete (Figure IV-7 and IV-8). All other features including the 1000 square yard riprap lining at the downstream end and the sheetpile channel end toe walls remain the same.

The construction material quantities and opinion of probable cost for this alternate are contained in Table IV-3.

4.4 Alternate Discussion

4.4.1 Alternate No. One

This alternate was selected for investigation because it is probably the most effective long term means of controlling erosion and scour in the Maline Creek and thus protect the resealed asbestos scrap site. Behind the considerable extra expense of lining the channel bed with revetment and the stream banks with concrete from Bellefontaine Road to the MSD drop structure lies a different approach to the project from that applied to Alternates one and two. Rather than merely treat the symptoms of erosion and scour by increasing the channel's bed and bank resistance to those forces; the approach seeks to eliminate some of the underlying causes by containing some of the flooding and erosion-scour forces at work.

One of those forces is the frequent flood cycle extant in the area. Even the 10% (10 year) storm causes minor flooding, while the 1% (100 year) event inundates homes in Bellefontaine Neighbors and the former asbestos factories. This is apparent from both

TABLE IV-3: Estimated Quantities and Opinion of Probable Cost for Alternate No. Three.

Item	Quantity	Unit Price ($)	Cost ($)
Clearing and Grubbing	7 AC.	4,000.00	28,000.00
Earthwork	10,000 Cu. Yd.	10.00	100,000.00
Onsite Asbestos Disposal	5,000 Cu. Yd.	25.00	125,000.00
12" Thick Gabion Revetment	7,400 Sq. Yd.	40.00	296,000.00
8" Geoweb 10" Conc. Syst.	5,800 Sq. Yd.	50.00	290,000.00
6" Geoweb 8" Conc. Syst.	5,600 Sq. Yd.	40.00	224,000.00
Geotextile Fabric	11,400 Sq. Yd.	2.00	22,800.00
6" Granular Filter	11,400 Sq. Yd.	5.00	57,000.00
Turf Reinforcement Matrix and Soil	8,500 Sq. Yd.	6.00	51,000.00
Sod	8,500 Sq. Yd.	2.00	17,000.00
Sheet Piling	3,000 Sq. Ft.	20.00	60,000.00
Sub Total			$1,270,800.00
Construction Contingencies (20%)			$ 254,200.00
TOTAL			**$1,525,000.00**

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the Corps of Engineers Re-evaluation Report Water Surface Profiles and FEMA Flood Insurance Rate Maps. Such flooding causes surface erosion when waters advance and recede, damages banks, and adds to the intensity and frequency of hydrostatic pressure loads on stream banks by thoroughly saturating the surrounding soil.

Alternate No. one will be designed to convey the 1% (100 year) flood through the area entirely within its banks. It will achieve this end by reducing channel roughness, increasing channel flow area, and most importantly by shifting the water surface control to the MSD drop structure where drawdown presently takes place. Hence the need to pave the reach from the bend to the structure.

Another of those forces to be contained operates along the reach parallel to St. Cyr Road from Bellefontaine Road to the tributary bend where Maline Creek is exercising its "tendency" to return to its meandering state. The road is being undermined as the creek attempts to re-establish its former channel. The concrete apron at the mouth of the tributary is at risk as well. Alternates two and three include 15 feet deep sheet piling across the full width of the creek at their upstream ends to block the undermining process. Over the long term however, this solution serves only as a temporary expedient subject to frequent inspection and repair as the creek attempts to bypass the sheet piling structure. By paving that portion of the channel and containing 1% (1 year) or lessor storms, the undermining forces maybe finessed.

4.4.2 Alternate No. Two

This alternate was investigated because it represents the least investment which could reasonably be expected to solve the immediate problems presented by the site. It is only a fair solution, however, because of uncertainties in the effectiveness of the reinforced soil bank in this particular application.

The two bends where scour poses the greatest problem are to be well armored with concrete, but the banks an both sides of the creek along the tangents between the bends are to be laid in at relatively mild slopes and then protected with a vegetated turf reinforcement matrix. Although channel hydraulics are improved. This alternate does not draw down flood water surface profiles. Thus the associated erosion and pressure forces previously mentioned will remain. Added to this is the natural tendency for fines to leach through soil banks as hydrostatic pressure is relieved. This results in the loss of supporting material as well as the fluid loading seen under frequent flooding conditions. The Simons, Li, and Associates study cited that very combination as the likely cause of failure of many four inches thick mesh reinforced concrete channel linings with 2 to 1 banks used in the watershed. The mild slope proposed, turf reinforcement matrix, and a well established vegetative cover with an extensive root system may well control those processes. But only a test of the system on site will yield enough information to provide confidence in its long term viability.

The St. Cyr Road undermining process in advance of the Riverview Branch Tributary bend will also remain with this alternate. The undermining currents can be temporarily blocked, but not eliminated unless the channel is fully paved to Bellefontaine Road. Periodic maintenance inspections and channel repair of scour holes upstream of the piling will be a yearly occurrance.

4.4.3 Alternate No. Three

This alternate addresses some of the uncertainties inherent in Alternate No. two. By paving the asbestos scrap material containing northeast banks with concrete and by providing proper drainage and filtration of the substrate, the concerns related to fluid pressure and soil leaching are somewhat alleviated. These measures will also increase the resistance capacity of the bank to the applied fluid forces, but will not change the frequency of loading as long as the flooding problems remain. As with Alternate No. 2, the St. Cyr Road undermining process is also present in this solution.

SECTION V

SECTION V

CONCLUSION - RECOMMENDATIONS

Alternate No. one represents the best opportunity to provide a reasonably permanent resolution of the problems presented by the Certainteed-GAF asbestos dump site at Maline Creek in St. Louis County, Missouri. In addition to sealing in the presently exposed asbestos scrap and protecting it from natural erosive hydraulic forces, it eliminates some of those forces as matters of concern. The solution also has the residual benefit of flood control in a FEMA flood plain where homes and businesses are at risk. For that reason it is possible that participation in the project may be forthcoming from other agencies interested in Maline Creek who have access to storm water management and or flood control funds. These may include the Missouri Department of Natural Resources, St. Louis Metropolitan Sewer District, St. Louis County, U.S. Army Corps on Engineers, Village of Bellefontaine Neighbors, and Village of Riverview Neighbors. If a joint venture among some of those parties can be effected, the U.S. Environmental Protection Agency's participation may be limited to the costs of the more expedient solutions.

If it is not possible for others to join with the EPA to construct Alternative No. one and complete funding for that alternative is not available to the agency, then TapanAm suggests Alternate No. three as a compromise selection. Its projected cost is only marginally greater than Alternate No. two for benefits that include concrete armored protection for the northeast asbestos storage streambank and greater confinement of fines. The design might also be adopted for future conversion to an Alternate No. one type solution.

APPENDIX

psi Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** **B-1** **PROJECT NUMBER:** 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992

APPX. DEPTH IN FEET	LABORATORY SAMPLE	PID READING (PPM)	LITHOLOGIC LOG	LITHOLOGIC DESCRIPTION
0				SURFACE (WEEDS)
0–2		–		CEMENT ASBESTOS MATERIAL MIXED WITH SAND, GRAVEL AND SILTY CLAY
2–4		–		
4–6		–		
6–8		–		
8–10		–		
10–12		–		
12–14		–		DARK BROWN SILTY CLAY (below approx. 13 ft)
14–16		–		
16–18		–		
18–20		–		
20				END OF BORING

Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** B-2 **PROJECT NUMBER:** 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992

APPX. DEPTH IN FEET	LABORATORY SAMPLE	PID READING (PPM)	LITHOLOGIC LOG	LITHOLOGIC DESCRIPTION
0				ASPHALT (SURFACE)
0–13		—		CEMENT ASBESTOS MATERIAL MIXED WITH FINE AND COARSE SAND
13–20		—		DARK BROWN SILTY CLAY (WET)
20				END OF BORING

Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** B-3 **PROJECT NUMBER:** 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992

APPX. DEPTH IN FEET | **LABORATORY SAMPLE** | **PID READING (PPM)** | **LITHOLOGIC LOG** | **LITHOLOGIC DESCRIPTION**

Depth scale: 0, 5, 10, 15, 20

PID readings: – (each interval, 0–20 ft)

0 ft: ASPHALT (SURFACE)

FINE AND COARSE SAND MIXED WITH SMALL AMOUNTS OF ASBESTOS MATERIAL

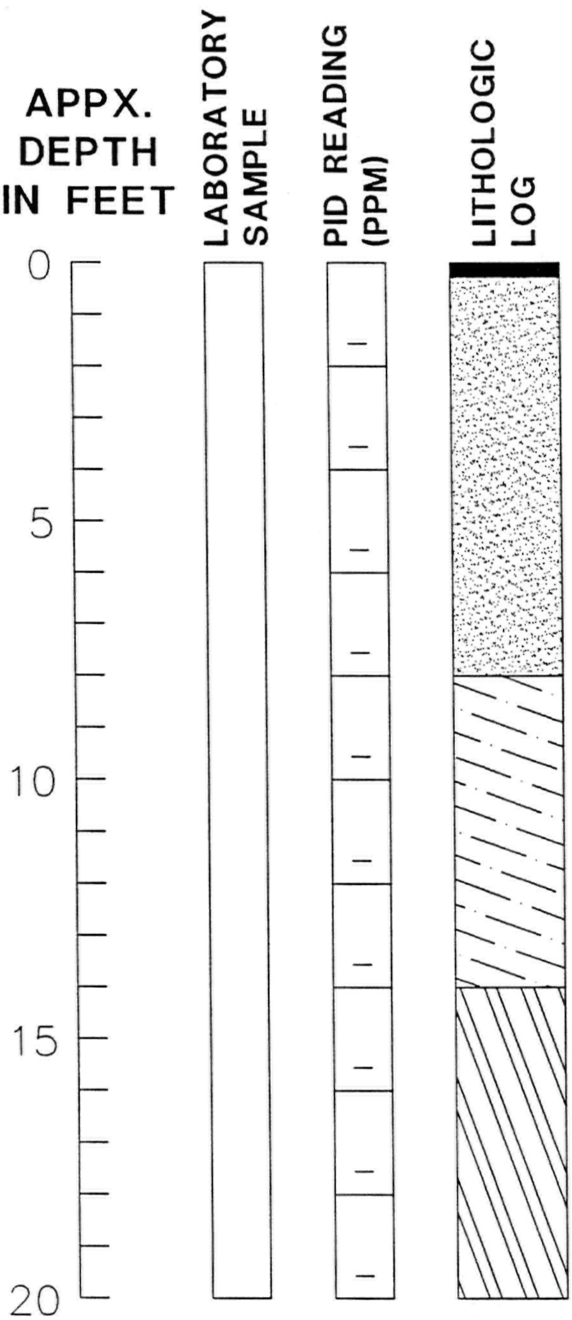
DARK BROWN SILTY CLAY (WET)

20 ft: END OF BORING

Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** B-4 **PROJECT NUMBER:** 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992



LITHOLOGIC DESCRIPTION

Appx. depth (ft)	Description
0	ASPHALT (SURFACE)
0 – 8	FINE AND COARSE SAND MIXED WITH SMALL AMOUNTS OF ASBESTOS MATERIAL
8 – 14	BROWN SILTY CLAY
14 – 20	GREY MOTTLED BROWN SILTY CLAY (WET) TRACE OF ASBESTOS MATERIAL
20	END OF BORING

psi Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** B-5 **PROJECT NUMBER:** 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992

APPX. DEPTH IN FEET	LABORATORY SAMPLE	PID READING (PPM)	LITHOLOGIC LOG	LITHOLOGIC DESCRIPTION
0				SURFACE (WEEDS)
0–7		– – – –		GREY FINE MEDIUM SAND WITH SOME ASBESTOS MATERIAL
7–13		– – – – – –		BROWN SILTY CLAY WITH VERY SMALL AMOUNTS OF ASBESTOS MATERIAL (WET)
13–20		– – – – – – –		DARK BROWN SILTY CLAY
20				END OF BORING

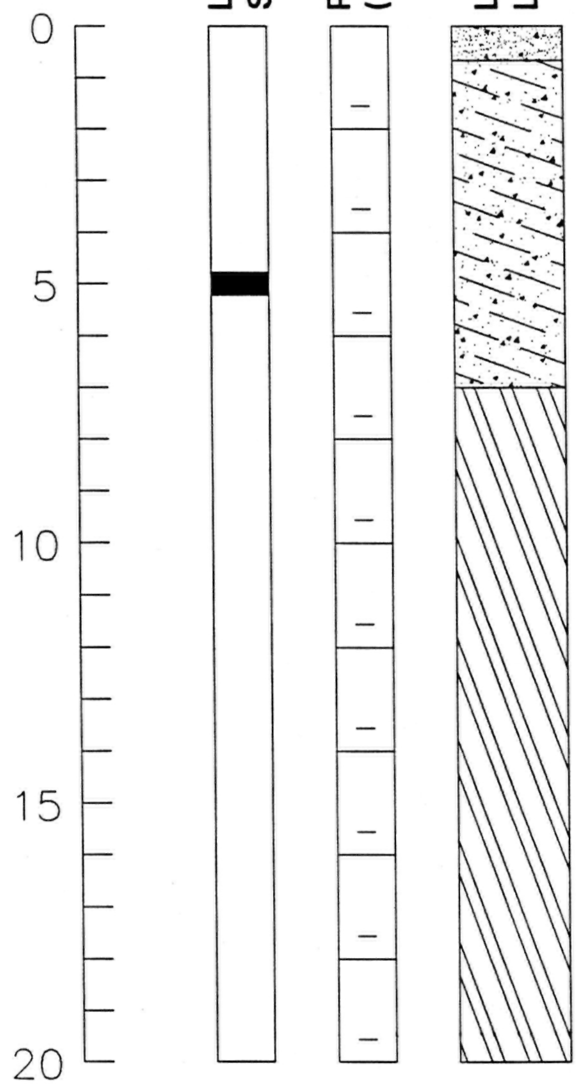
psi Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** B-6 **PROJECT NUMBER:** 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992

APPX. DEPTH IN FEET | LABORATORY SAMPLE | PID READING (PPM) | LITHOLOGIC LOG

LITHOLOGIC DESCRIPTION



SURFACE (GRAVEL)

LIGHT BROWN FINE COURSE SAND WITH SOME GRAVEL

BROWN SILTY CLAY/TRACE OF GRAVEL WITH SMALL AMOUNTS OF ASBESTOS MATERIAL

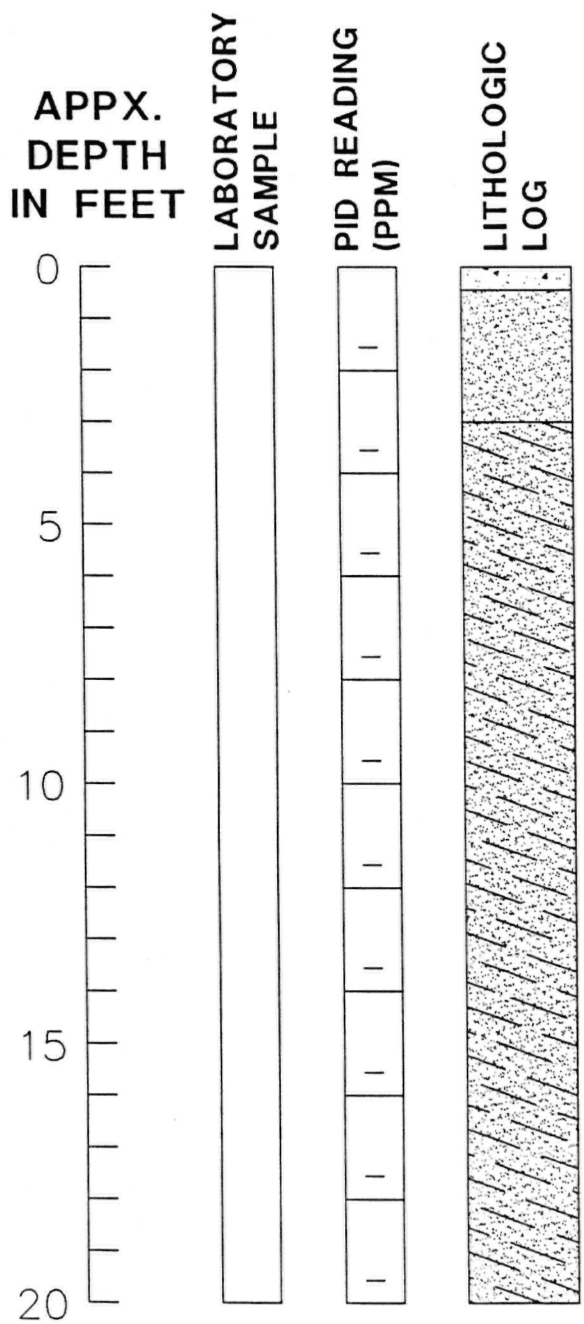
DARK GREY SILTY CLAY (WET)

END OF BORING

Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** B-7 **PROJECT NUMBER:** 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992



LITHOLOGIC DESCRIPTION

SURFACE (CONCRETE)

BROWN FINE TO MEDIUM SAND

BROWN SILTY CLAY WITH SOME ASBESTOS MATERIAL

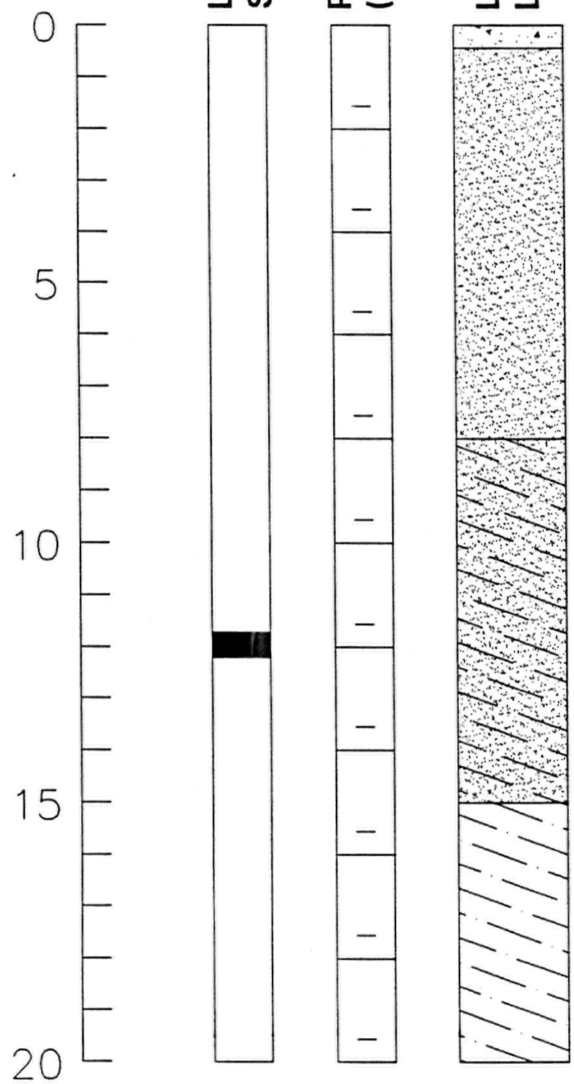
END OF BORING

Professional Service Industries, Inc.
4820 West Fifteenth Street
Lawrence, Kansas 66049

SOIL BORING LOG

SOIL BORING IDENTIFICATION:	B-8
PROJECT NUMBER:	60829051
PROJECT:	MALINE CREEK ASBESTOS ABATEMENT
LOCATION:	ST. LOUIS, MISSOURI
ENGINEER:	K. DEMOTT
DRILLING METHOD:	PROFILE AUGER
SAMPLING INTERVAL:	INTERMITTANT
DRILLING CONTRACTOR:	PSI, INC.
BOREHOLE DIAMETER:	3.5 INCH O.D.
SAMPLING METHOD:	PROFILE AUGER
DRILLER:	M. SIMMERING
TOTAL BORING DEPTH:	20 FEET
DATE BORING COMPLETED:	DEC. 12, 1992

APPX. DEPTH IN FEET | **LABORATORY SAMPLE** | **PID READING (PPM)** | **LITHOLOGIC LOG**



LITHOLOGIC DESCRIPTION

SURFACE (CONCRETE)

FINE MEDIUM SAND MIXED WITH ASBESTOS MATERIALS

BROWN SILTY CLAY (WET) MIXED WITH ASBESTOS MATERIALS

DARK BROWN SILTY CLAY

END OF BORING

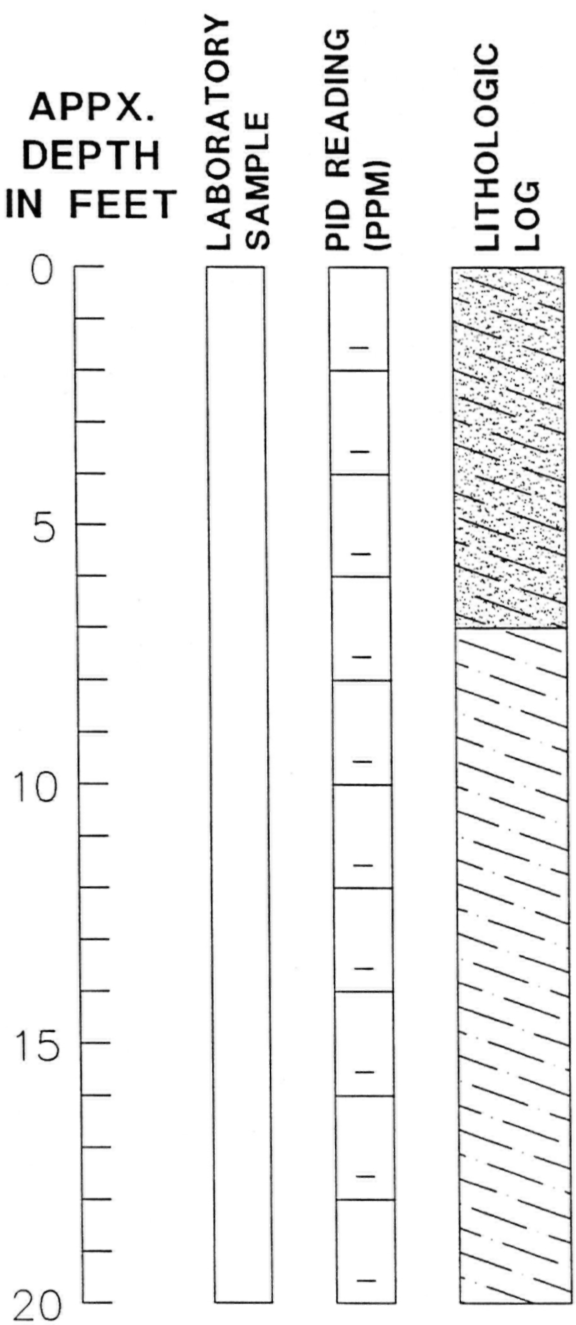
psi Professional Service Industries, Inc.
4820 West Fifteenth Street
Lawrence, Kansas 66049

SOIL BORING LOG

SOIL BORING IDENTIFICATION:	B-9
PROJECT NUMBER:	60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992



LITHOLOGIC DESCRIPTION

SURFACE (GRASS)

BROWN SILTY CLAY WITH SMALL AMOUNTS OF ASBESTOS MATERIALS

BROWN SILT CLAY

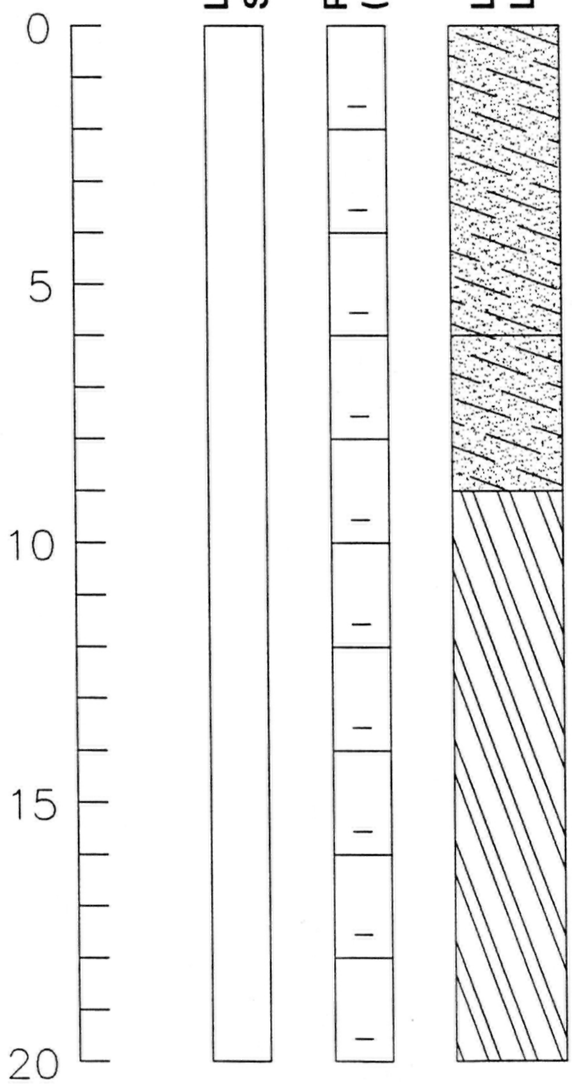
END OF BORING

Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	SOIL BORING LOG	SOIL BORING IDENTIFICATION: B-10 PROJECT NUMBER: 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	LOCATION: ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	DRILLING METHOD: PROFILE AUGER	SAMPLING INTERVAL: INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	BOREHOLE DIAMETER: 3.5 INCH O.D.	SAMPLING METHOD: PROFILE AUGER
DRILLER: M. SIMMERING	TOTAL BORING DEPTH: 20 FEET	DATE BORING COMPLETED: DEC. 12, 1992

APPX. DEPTH IN FEET | LABORATORY SAMPLE | PID READING (PPM) | LITHOLOGIC LOG | LITHOLOGIC DESCRIPTION



BROWN SILTY CLAY MIXED WITH ASBESTOS MATERIALS

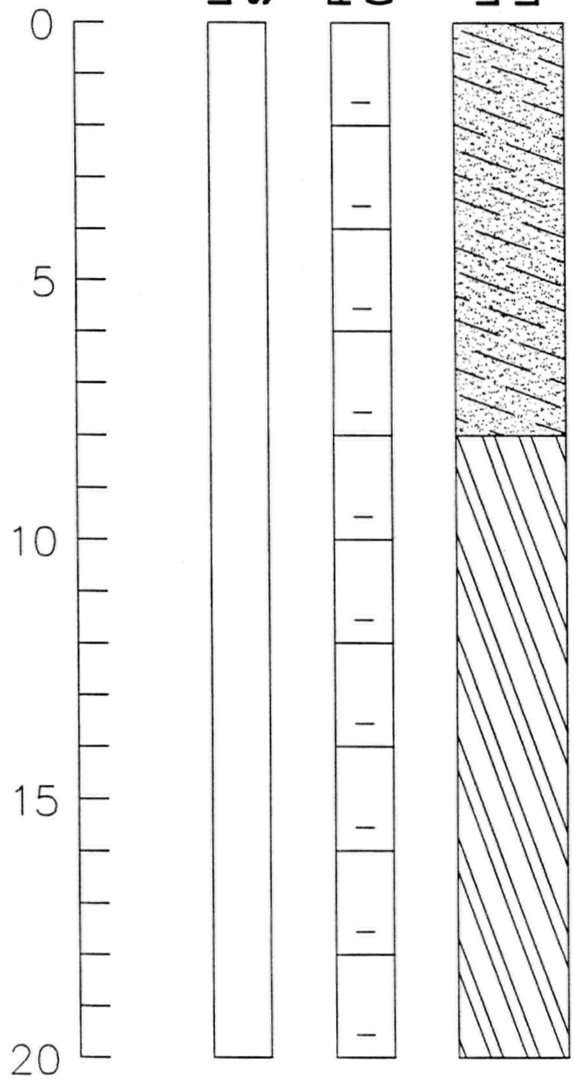
DARK BROWN SILTY CLAY
MIXED WITH ASBESTOS MATERIALS (WET)

GREY CLAYEY SILT

END OF BORING

Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** B-11 **PROJECT NUMBER:** 60829051
PROJECT: MALINE CREEK ASBESTOS ABATEMENT		**LOCATION:** ST. LOUIS, MISSOURI
ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992

APPX. DEPTH IN FEET | **LABORATORY SAMPLE** | **PID READING (PPM)** | **LITHOLOGIC LOG** | **LITHOLOGIC DESCRIPTION**



BROWN SILTY CLAY MIXED WITH ASBESTOS MATERIALS

DARK GREY CLAYEY SILT (WET)

END OF BORING

psi Professional Service Industries, Inc. 4820 West Fifteenth Street Lawrence, Kansas 66049	**SOIL BORING LOG**	**SOIL BORING IDENTIFICATION:** B-12 **PROJECT NUMBER:** 60829051

PROJECT: MALINE CREEK ASBESTOS ABATEMENT	**LOCATION:** ST. LOUIS, MISSOURI

ENGINEER: K. DEMOTT	**DRILLING METHOD:** PROFILE AUGER	**SAMPLING INTERVAL:** INTERMITTANT
DRILLING CONTRACTOR: PSI, INC.	**BOREHOLE DIAMETER:** 3.5 INCH O.D.	**SAMPLING METHOD:** PROFILE AUGER
DRILLER: M. SIMMERING	**TOTAL BORING DEPTH:** 20 FEET	**DATE BORING COMPLETED:** DEC. 12, 1992

APPX. DEPTH IN FEET	LABORATORY SAMPLE	PID READING (PPM)	LITHOLOGIC LOG	LITHOLOGIC DESCRIPTION
0 – 8		– – – –		BROWN SILTY CLAY AND GRAVEL MIX WITH SMALL AMOUNTS OF ASBESTOS MATERIALS
8 – 20		– – – – – –		BROWN GREY CLAYEY SILT (MOIST) MIXED WITH ASBESTOS MATERIALS
20				END OF BORING

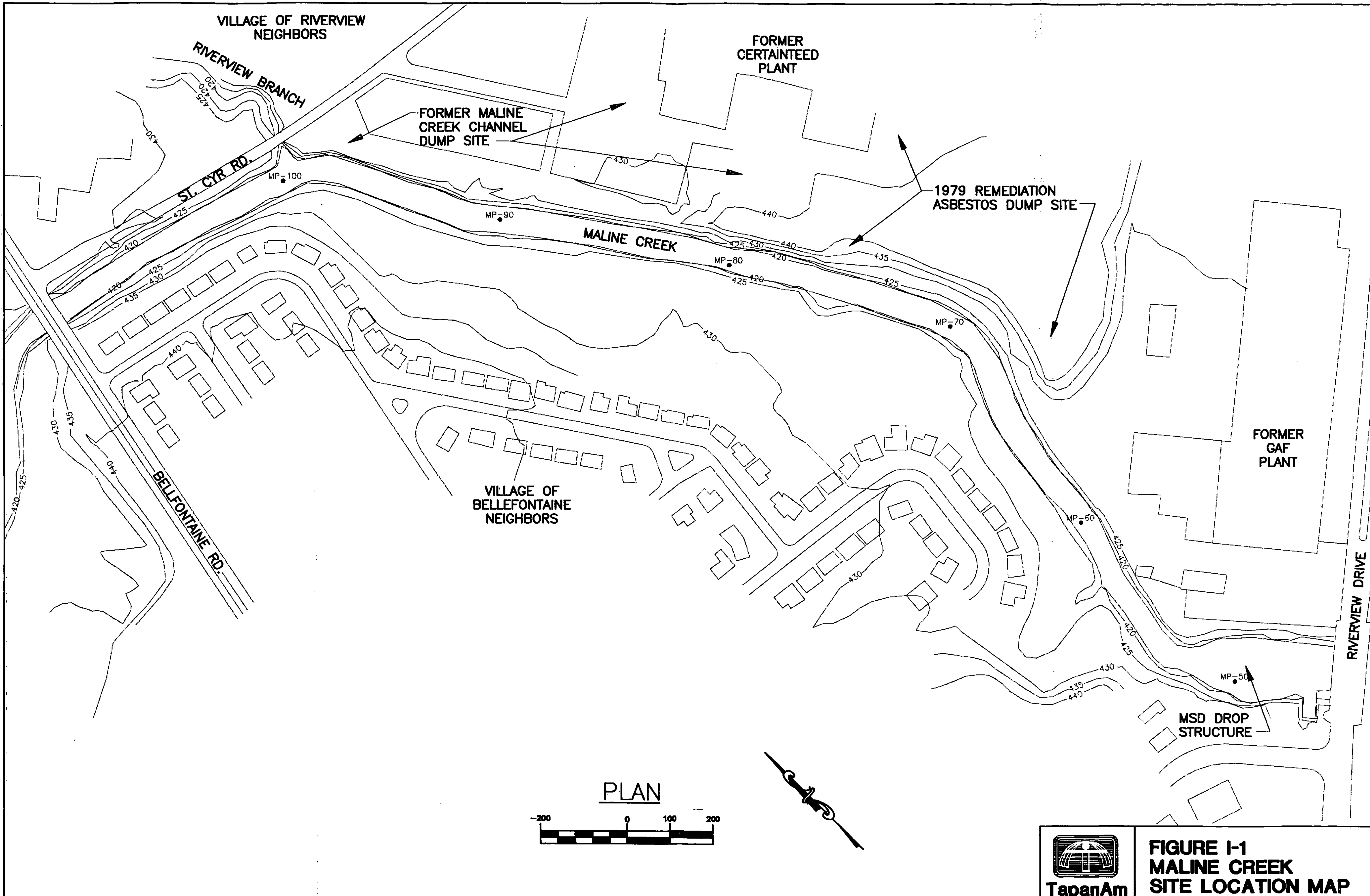


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FIGURE I-1
MALINE CREEK
SITE LOCATION MAP

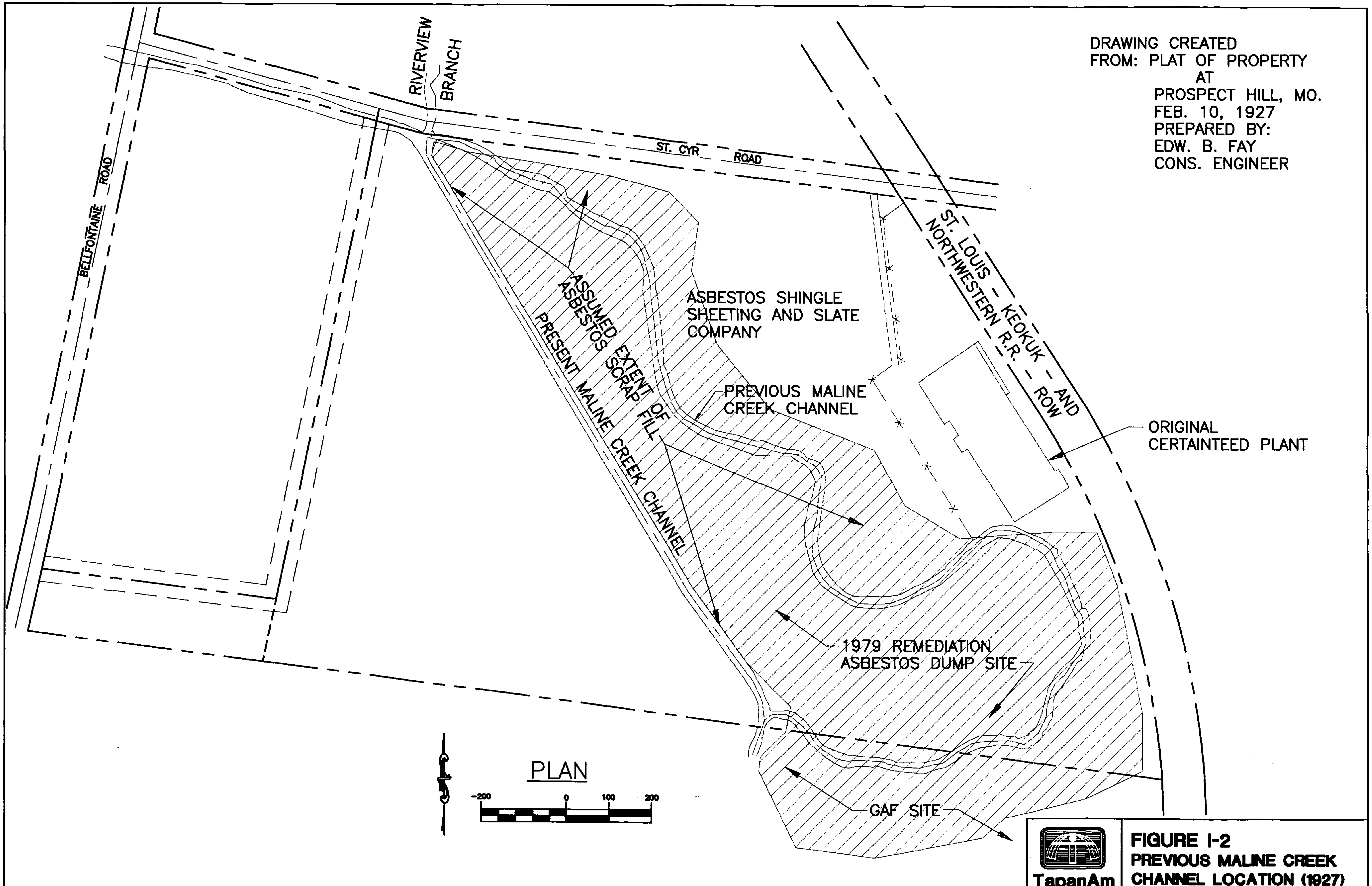

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FIGURE I-2
PREVIOUS MALINE CREEK CHANNEL LOCATION (1927)

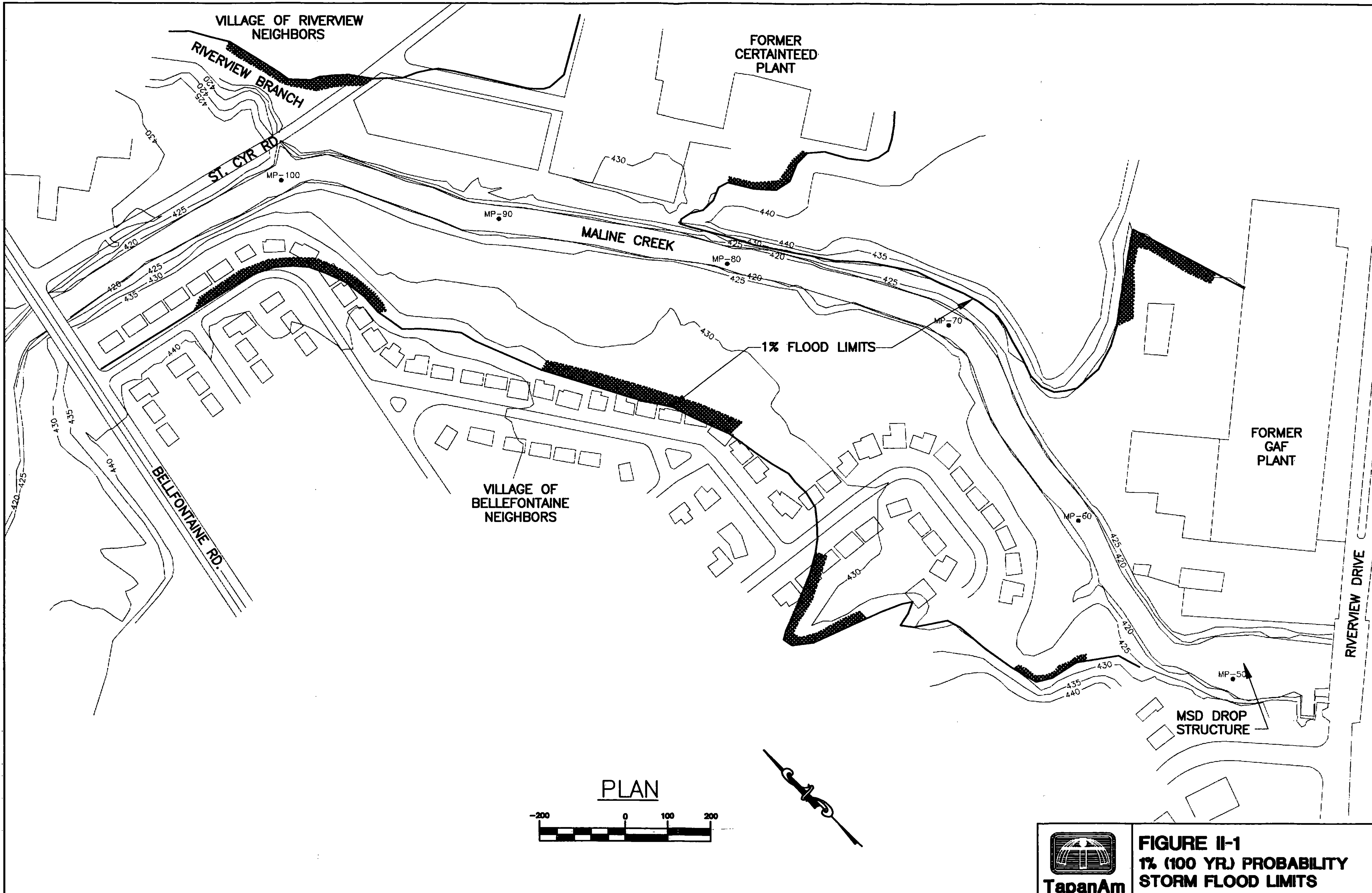


FIGURE II-1
1% (100 YR.) PROBABILITY
STORM FLOOD LIMITS

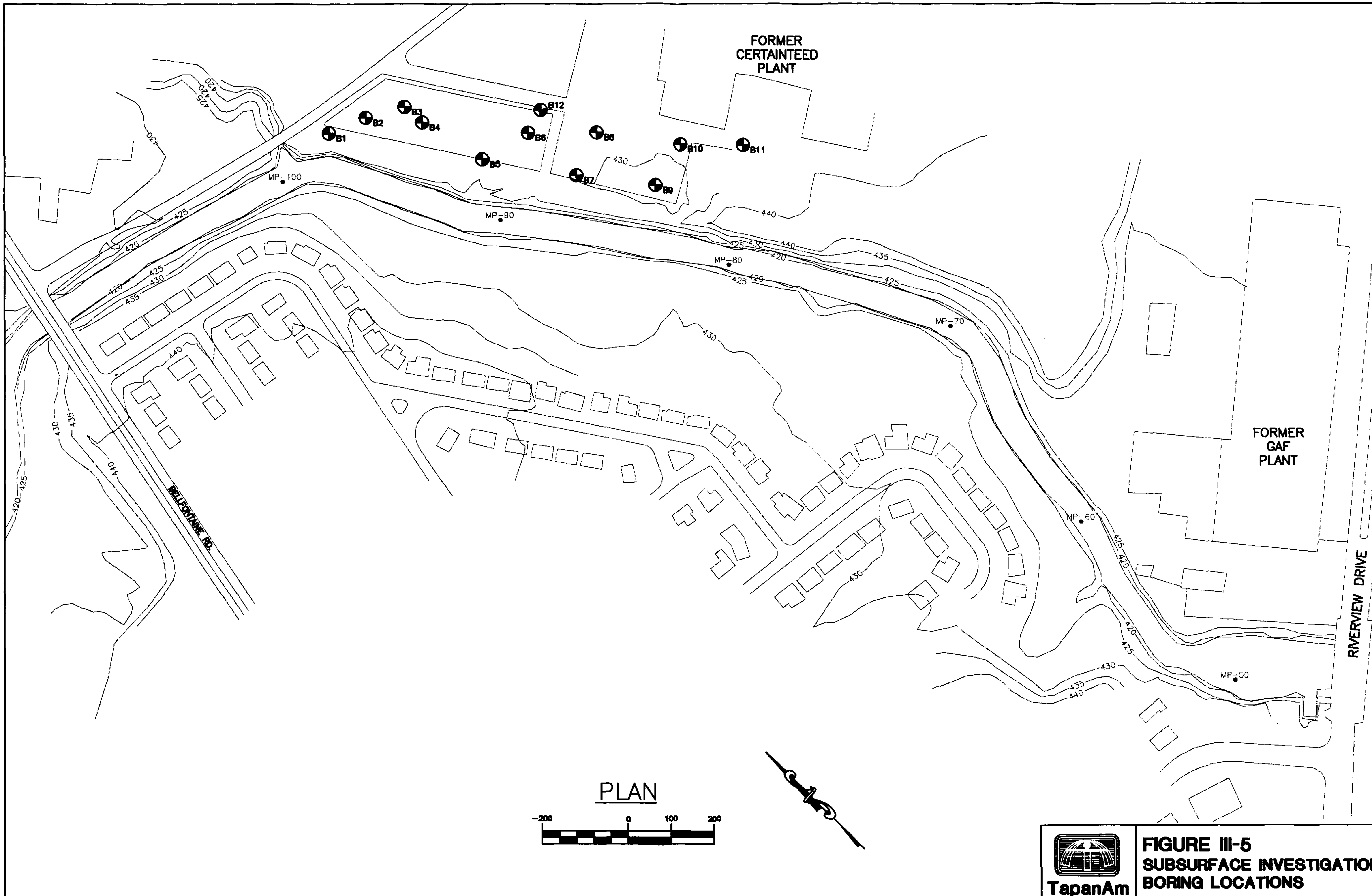


FIGURE III-5
SUBSURFACE INVESTIGATION
BORING LOCATIONS

TapanAm

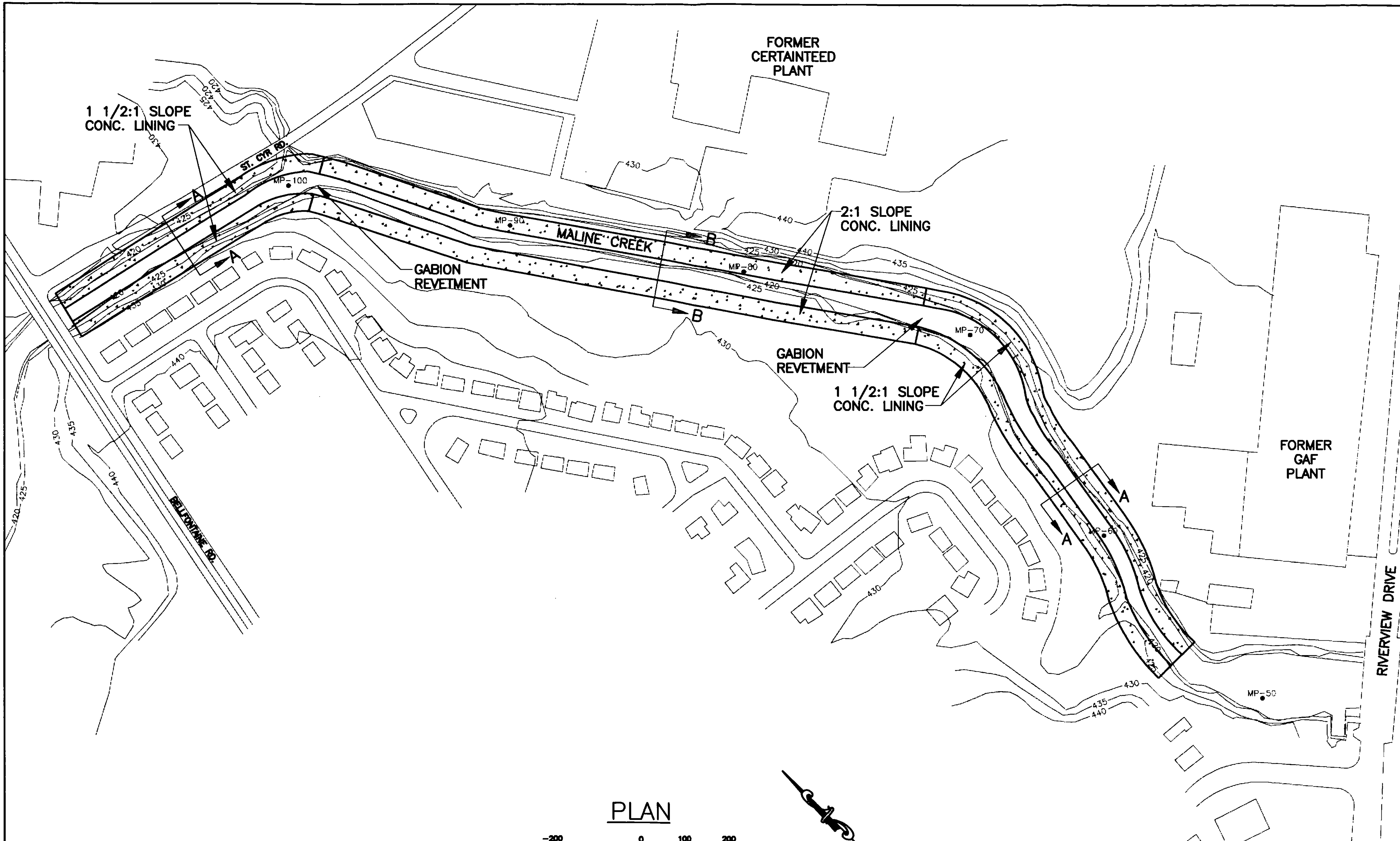
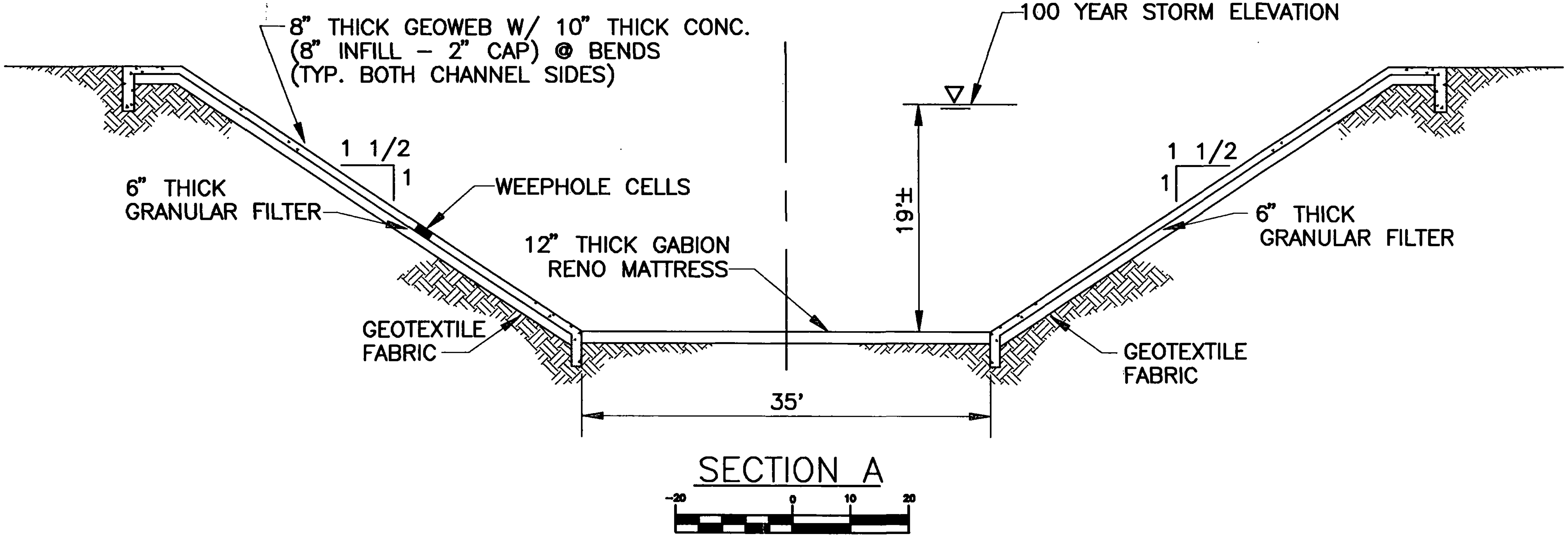
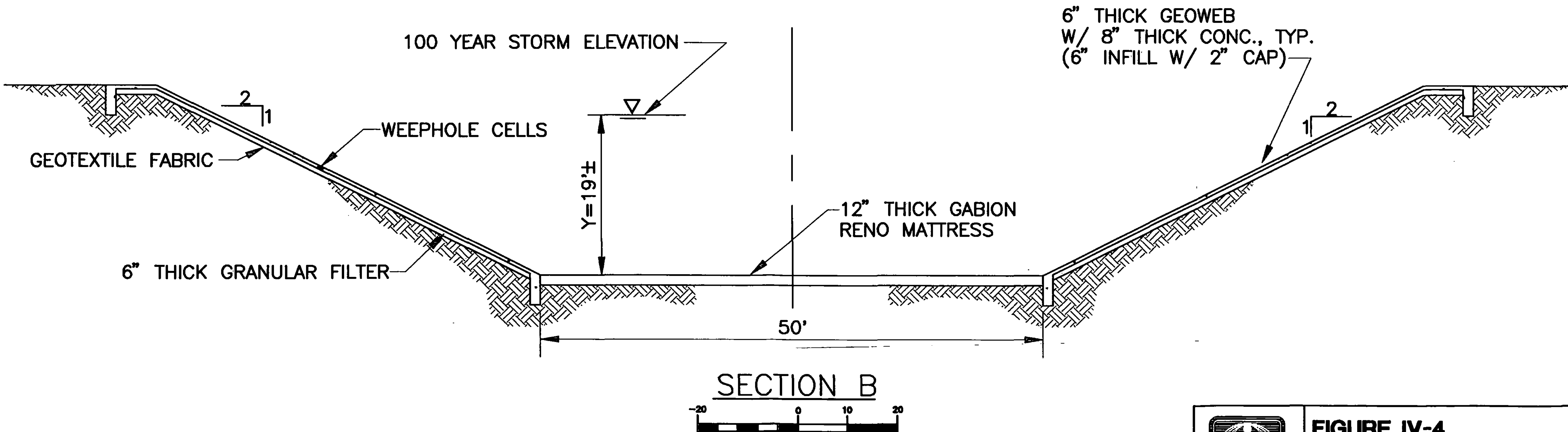


FIGURE IV-3
ALTERNATE NO.1 PLAN

TapanAm



SECTION A



SECTION B

TapanAm

FIGURE IV-4
ALTERNATE NO.1
SECTIONS

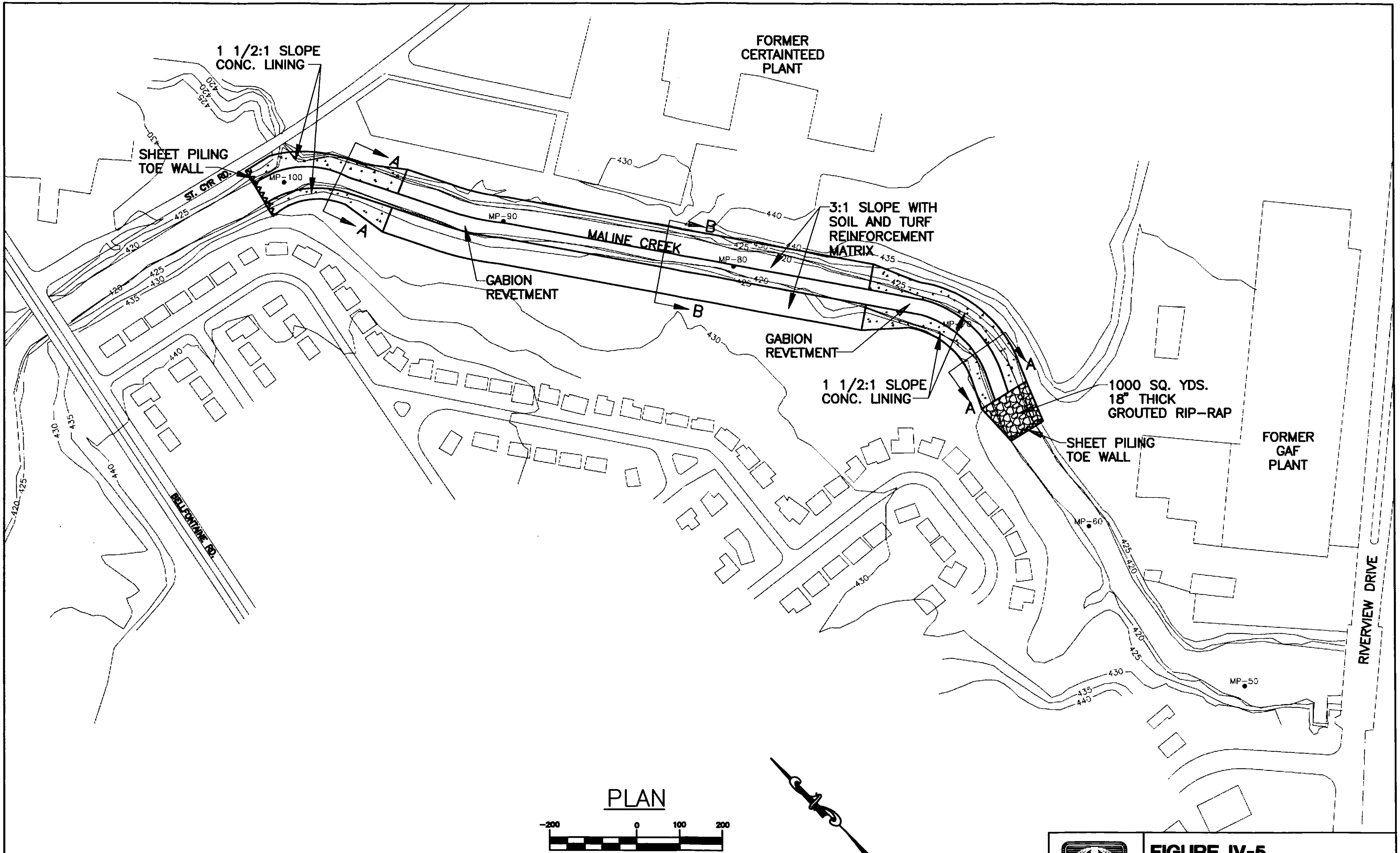
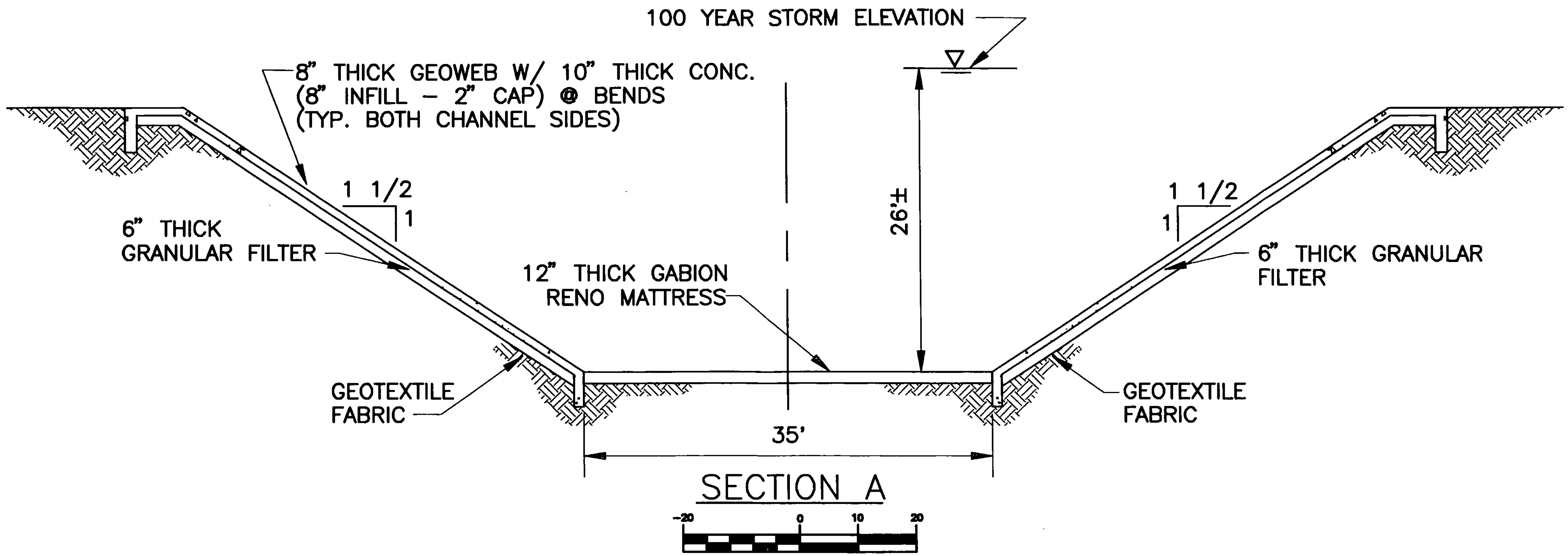


FIGURE IV-5
ALTERNATE NO.2 PLAN

TapanAm



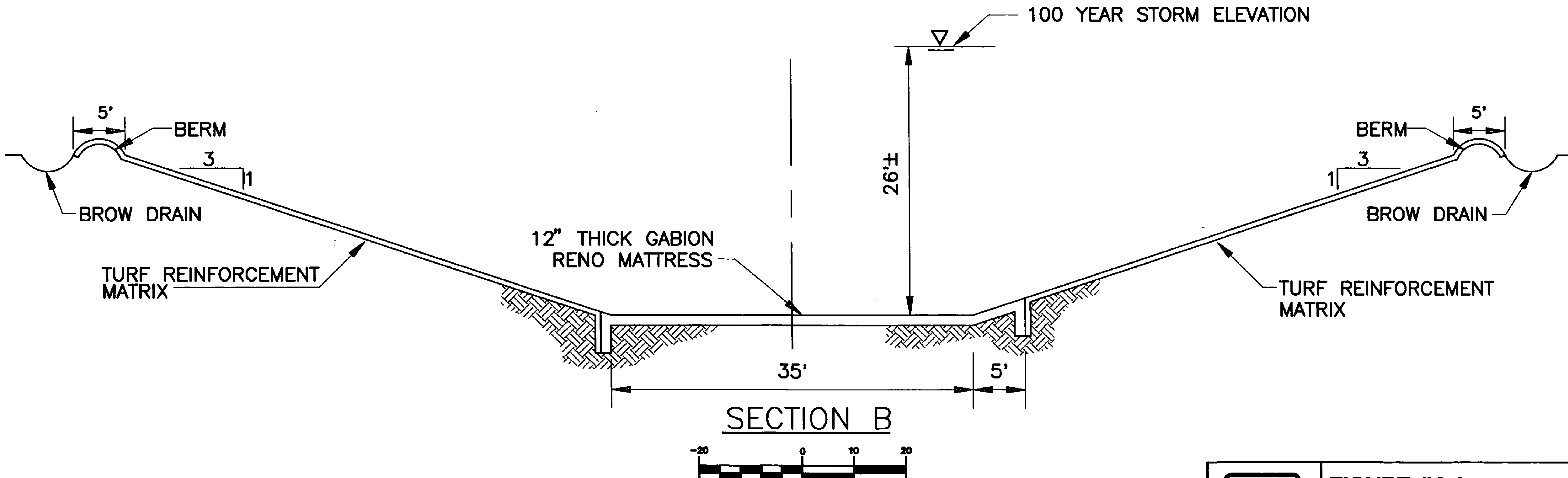


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FIGURE IV-6
ALTERNATE NO.2
SECTIONS

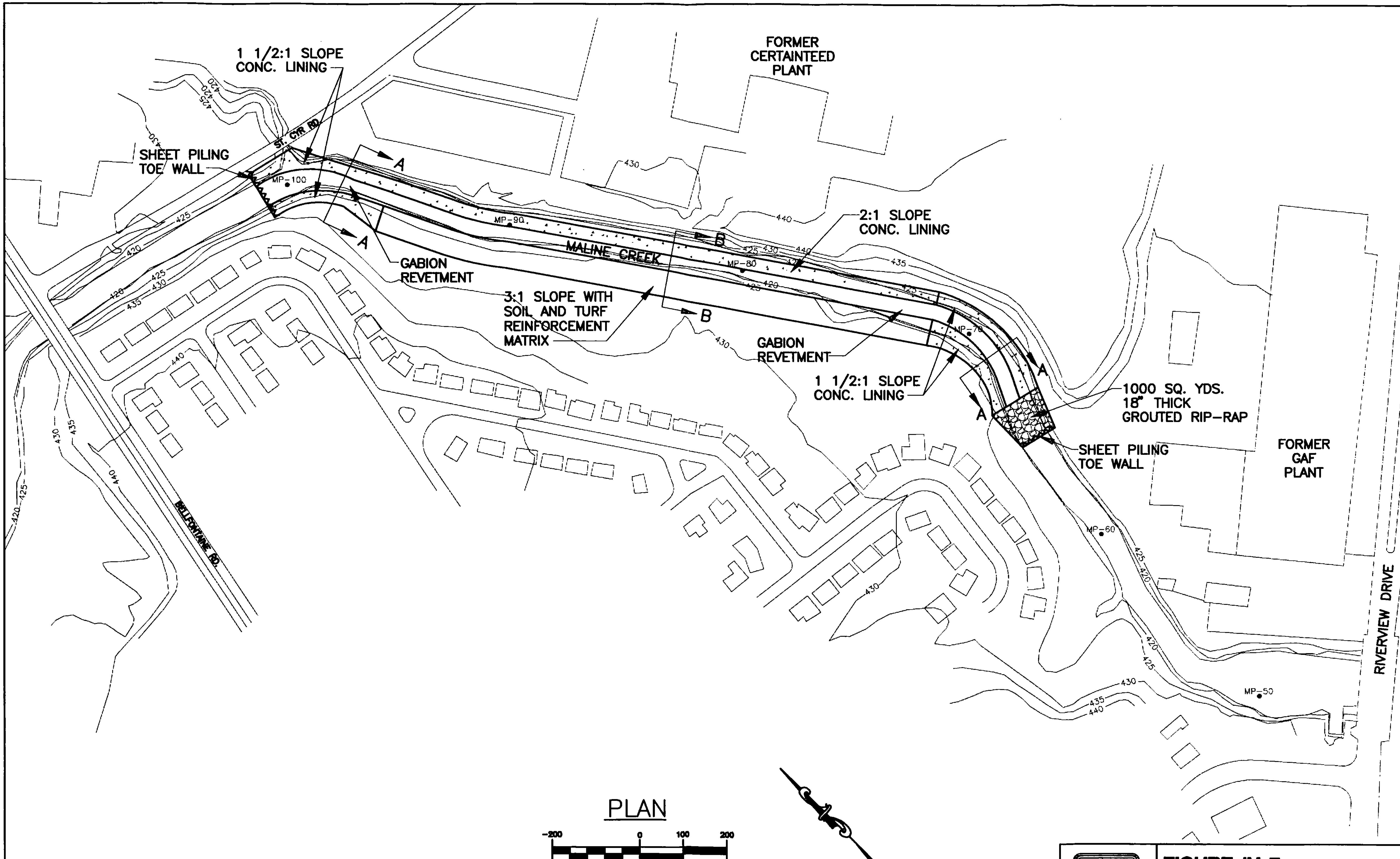

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FIGURE IV-7
ALTERNATE NO.3 PLAN

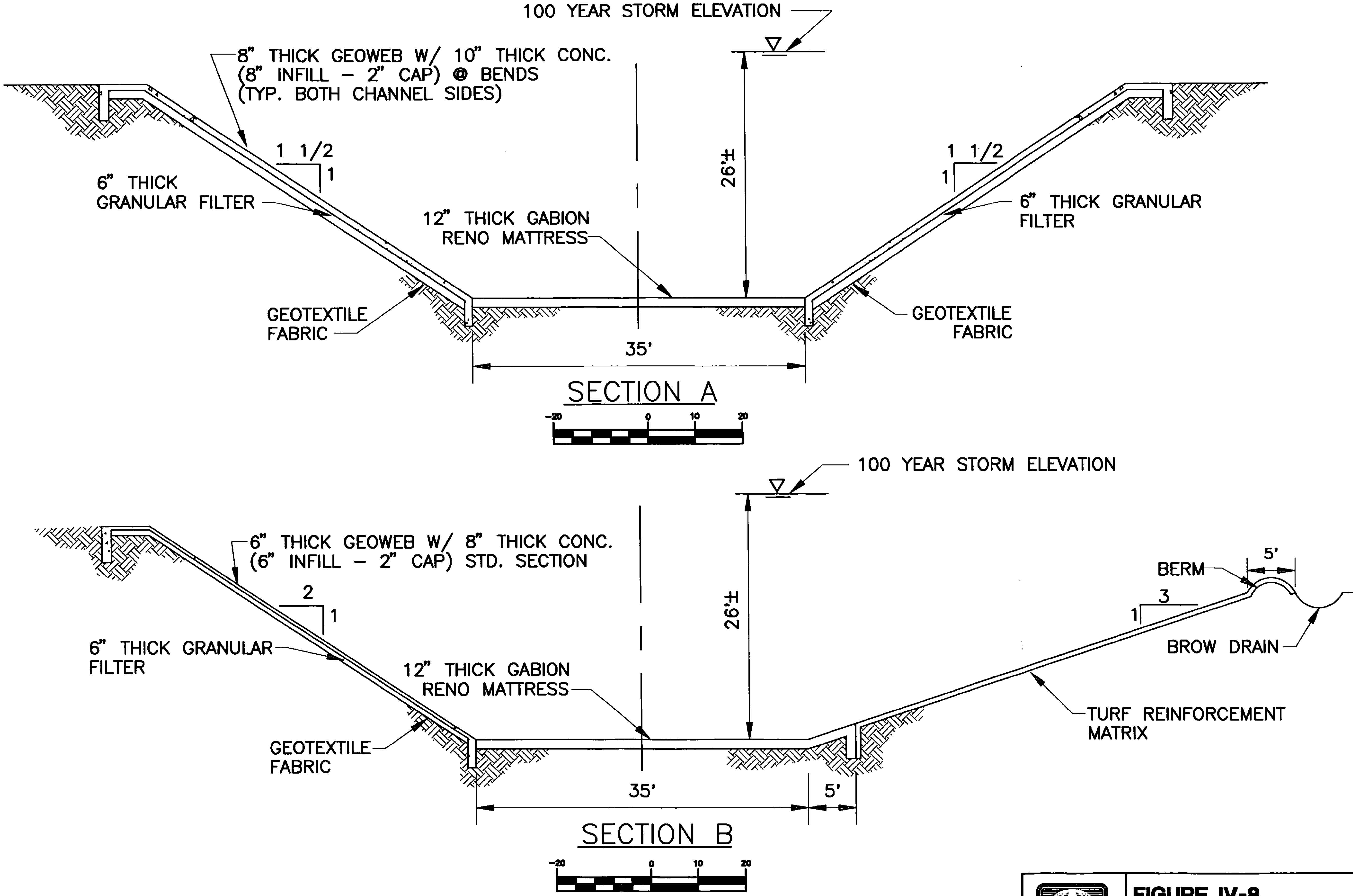

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FIGURE IV-8
ALTERNATE NO.3
SECTIONS